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A Seven-Day Journal

Empire Air Services

IN one of last week's Journal notes we referred to the decision of Imperial Airways to reduce substantially as from Wednesday, August 9th, the passenger accommodation on its Empire air routes. This statement has been interpreted in certain quarters as a refusal to carry any more passengers on the Empire air routes, during the next few months, and in consequence many inquiries have reached Airways House from future passengers who have already made their reservations. It is now stated by Imperial Airways that all definite bookings which have already been made are still valid. While it is pointed out there has been a drastic and inevitable curtailment of the accommodation for passengers travelling from London on the Empire air routes, the company intends to make the fullest use of the accommodation which is still available. It is stated that passengers who are travelling northwards or westwards to London will find that the available accommodation is far less restricted. There is also, it is announced, a certain amount of accommodation for passengers who are travelling between intermediate stations on the Empire routes.

A Tube Trade Merger

ON Friday, August 11th, the full terms of the proposed merger between Stewarts and Lloyds, Ltd., and the Stanton Ironworks Company, Ltd., was made known, and circulars were issued to the stockholders of each of the two companies. The scheme provides for the taking over of all the stock of the Stanton Ironworks Company, Ltd., by Stewarts and Lloyds, Ltd., the Stanton stockholders receiving appropriate Stewarts and Lloyds' shares. In recommending this offer to its shareholders, the Stanton Company points out that both firms have adopted a policy of rationalisation in their respective branches of the pipe and tube trades, and that each has achieved pre-eminence in its own sphere. The time has now arrived, it is stated, to carry rationalisation a step further by amalgamating the interests of both firms. Both companies, it is pointed out, control large resources of iron ore and both produce pig iron at a relatively low cost. Many advantages can be secured by the pooling of resources, and by co-operating benefits can be derived, especially in the export market. In the Stewarts and Lloyds' circular, these views are repeated, and the provision of necessary capital to finance the scheme is recommended. The circulars also announce the proposed interlocking of the boards of the two companies. Mr. E. J. Fox, the managing director of the Stanton Company; Mr. J. N. Derbyshire, the prospective chairman, and one of the other present directors of the Stanton Company, will join the Stewarts and Lloyds board. Mr. J. N. Derbyshire will become the chairman of the Stanton Company, and of the other present directors, Sir W. Benton Jones, Mr. F. Le Neve-Foster, Mr. E. J. Fox, and Mr. T. Sarson will remain, while four directors of Stewarts and Lloyds, including Mr. A. C. Macdiarmid, the chairman, and Sir Nigel Campbell, the deputy chairman, will join the Stanton Company's board. The present chairman of the Stanton Iron Works Company, Ltd., Mr. C. R. Crompton, together with Mr. G. W. Crompton, Mr. C. E. Lloyd, and Mr. J. F. Crompton-Inglefield, are to retire from the Stanton board and will receive compensation. It is provided that Mr. E. J. Fox should remain managing director of the Stanton Company, and Mr. T. Sarson, the assistant managing director. The scheme now awaits the approval of the shareholders of both companies.

Ironstone Areas Restoration

ON Monday, August 14th, the report of a Committee which was appointed in 1938 by Sir Kingsley Wood, then Minister of Health, to investigate the problems raised by the destruction of agricultural land in Northamptonshire and the neighbouring counties, as the result of the excavation of iron ore, was published by the Stationery Office. The principal recommendation made by the Committee, which sat under the chairmanship of Lord Kennet, is the proposal that a special body should be set up, which would probably be known as the Ironstone Areas Restoration Board, to deal with the work of restoration. It would consist of representatives of local authorities, landowners, mining companies, and the Forestry Commissioners, and an independent chairman, appointed by the Ministry of Agriculture. In the report it is stated that there are about 109,000 acres of land containing ironstone deposits, which are found in North and South Lincolnshire, East Leicestershire, Rutland, Northamptonshire, and North Oxfordshire. Near Corby, in Northamptonshire, excavators designed to deal with 500 tons of soil per acre, and to dig up the land in order to reach the iron ore at 50ft. to 60ft. below the surface are employed, which throw the overburden on one side, thereby forming gigantic furrows, locally known as "hill and dale." The surface of land which will likely be destroyed and not restored is estimated to amount to close upon 80,000 acres. At present the amount of land devastated is less than 250 acres each year, but the annual rate is likely to increase and to go on for 250 years. Complete restoration for agriculture cannot, it is felt, provide a solution for the greater part of the area, as the cost of levelling, together with the replacement or non-replacement of the top soil may exceed £100 per acre. That being so, agriculture can only at best play a subsidiary part in the solution of the problem. The main alternative to restoration for agricultural purposes is afforestation, which is much cheaper and does not necessitate the levelling of the land. It is appreciated that the Board would do much of its work through the Forestry Commissioners, but at the same time it should have a free hand to undertake agricultural restoration or any other form of restoration, whenever it was thought it could be done with advantage.

Railway Wages

ON Monday, August 14th, the general managers of the four main line railway companies met representatives of the National Union of Railwaymen and the Railway Clerks' Association in London, when further discussions took place in connection with the claim of the National Union of Railwaymen for a minimum wage of 50s. per week. The meeting lasted for an hour and forty minutes, and ended in a complete deadlock, the companies intimating that their present financial position did not justify any further increase in the minimum rate of 45s., which was recently conceded and has been paid for a fortnight. It is understood that at the meeting no new claims were submitted by the Railway Clerks' Association. It is stated that the cost to the railway companies of conceding the claim made by the National Union of Railwaymen would amount to a minimum of over a million pounds, and might rise to over 2½ million pounds were all grades covered. The demand of the union is characterised as a reasonable and modest claim, and it was put forward after a special delegate conference held last week in London. On Wednesday a meeting of the executive committee was held, and it was decided to call another delegate conference early next week, to which the companies' reply will be reported. Meanwhile, the negotiations between the railway companies and the Associated Society of Locomotive Engineers and Firemen are being continued, and on Wednesday a further meeting was held to continue the discussions which were adjourned on Thursday, August 10th, after a two-hour talk, in order to enable the companies to give the matter further consideration. It may be recalled that the locomotive men are claiming an increase in wages, longer paid holidays, abolition of the permissive roster of nine hours per day, and an improvement in the pay for Sunday labour.

A Fen Drainage Scheme

IN April last Sir Murdoch MacDonald, it will be recalled, was invited by the Ministry of Agriculture to prepare a scheme, in connection with the Great Ouse Catchment Board, for the protection of the Fens from the danger of flooding. The report of Sir Murdoch MacDonald has now been completed, and the engineers of the Board are working on the plan and are carrying out the necessary survey work connected with it. The plan, we are given to understand, embodies the construction of a channel at a high level following the contour of the land, which will collect the water from the rivers and their tributaries when flooded. This proposed channel will begin close to Cambridge and, following high ground, will pass near Newmarket, Mildenhall, Brandon, and Downham Market, reaching the main drainage outlet some 5 miles upstream from the Wash, at a point between Denver Sluice and King's Lynn. Starting with the Cam, the rivers will include the Wissey, the Lark, and the Little Ouse, and the channel will be siphoned under these rivers, suitable by-pass connections being provided. It will be appreciated that any scheme of this nature, which cuts across the country, will involve, of necessity, the construction of several bridges in order to allow the existing railway lines and roadways to be carried over the high-level collecting channel. The scheme put forward by Sir Murdoch MacDonald and Partners, of 72, Victoria Street, Westminster, has the advantage, it is claimed, that the proposed channel will only be used to carry away flood waters, and very little pumping will be required, as the flow will largely be by gravity. Moreover, the existing *régime* of the rivers involved in the scheme will not be disturbed and there will be no interference with their navigation rights. According to officials of the Catchment Board, the cost of the scheme, which will be available for Government grant, will be in the neighbourhood of £2,500,000. At the present time, we are informed, the scheme is only in the preliminary stage, and a considerable amount of survey work has still to be completed. It is therefore probable that some modifications to the scheme we have briefly outlined above may be made.

An Engineering Works Amalgamation

IN the course of his speech at the annual general meeting of the Davy and United Engineering Company, Ltd., which was held at Sheffield on Friday, August 11th, Mr. E. J. Fox, the chairman of the company, referred to the agreement whereby his firm has acquired the whole of the share capital of Duncan Stewart and Co., Ltd., of Glasgow. He said that for some considerable time his colleagues on the board and he himself had felt that if we in this country were to recover and to maintain our position as the foremost builders of steel works plant for satisfying the requirements of this country and of foreign countries, we were required to create a group, strong in management, in technical personnel, and in designing ability, with sufficient works capacity to give reasonable deliveries to our customers. The firm had taken steps to achieve that end by extending its Sheffield works, by linking up with the United Engineering and Foundry Company, and by acquiring the allied business in Middlesbrough. Now, by the further acquisition of Duncan Stewart and Co., Ltd., it had been possible to contribute towards the aim above referred to by adding to the personnel and works capacity, and by merging specialised knowledge of steel works plant. The firm of Duncan Stewart had a good reputation in the steel industry, particularly in the manufacture of forging presses, and the recent fusion of interests formed a group capable of designing and building a complete range of steel works equipment. Mr. Fox said that in connection with the amalgamation of interests, it was proposed that Mr. J. P. Talbot-Crosbie and Mr. W. Kilpatrick, directors of Duncan Stewart and Co., Ltd., both of whom were well known in the steel industry, should join the board of the Davy and United Engineering Company, Ltd.

Progress in the Special Areas

THE reports of the Commissioners for Special Areas in England and Scotland, which have just been issued, show clearly the progress which is being made in the direction of establishing new industries and providing increased employment in these parts. According to the report of Sir James Price, the Commissioner for the Special Areas in England and Wales, issued on Tuesday, August 15th, an amount in excess of £26,000,000 has now been spent on these areas, which does not include the capital brought in by new firms established on the trading estates. In Durham and on Tyneside the report states that the number of completed factories is now 136, giving employment to 3719 people, while in South Wales 68 factories have been completed, giving employment to 4578 people. The men who are employed on development and construction work on the Treforest Trading Estate number 652, while there are 199 employed on other industrial sites. In West Cumberland eight factories have been established, giving employment to 503 workers. At the end of July the Commissioner's total commitments were:—Grants to industry, £6,464,000; grants for land settlement, £3,283,000; public health schemes, £6,677,000; and other grants, £3,096,000; making a total of £19,520,000. The report of Lord George Nigel Douglas-Hamilton, the Commissioner for Special Areas in Scotland, announces that during July commitments amounting to about £204,000 were entered into for the further economic development and social improvement of the areas. On the Hillington Industrial Estate, 82 firms were occupying 121 factories, and some 600 persons were employed on the development of the four estates, including the Lanarkshire estates. The Commissioner's total commitments to date amount to over £5,580,000, while on completion the schemes excluding the capital brought into the area by firms, will amount to about £9,693,000. In connection with the work of developing these special areas, our readers will learn with regret of the death on Thursday August 10th, at Letchworth, of Sir George Gillett, who was the Commissioner for England and Wales from 1936 until his resignation in May last on account of ill-health. George Masterman Gillett came of Quaker stock, and was born in Islington in 1870. He was educated at Scarborough and at Paris, and became a partner in 1894 in the banking firm of Gillett Brothers. He will be long remembered for his work in connection with the Peel Institute, London, the Finsbury Borough and London County Councils, and his services to the Government, especially his work for the Special Areas, and the many helpful suggestions he made and carried out for the training of the young and long-term unemployed.

A History of Rotary Engines and Pumps

PART II.—No. IV

(*Continued from page 150, August 11th*)

Gear Pumps

IT would be difficult to calculate how much of the present success of the gear pump is due to the rapid development of the use of gearing in other applications. The debt must certainly be large. But since, as was pointed out in one of the articles in the first part of this series, the gear pump must be designed as a satisfactory compromise between the requirements for good gearing and good pumping, something more than the development of gearing in other applications was necessary before the gear pump could be brought to its present state of high efficiency. In the early years of the present century, it was soon discovered that to obtain good gearing qualities with involute teeth, a large number of teeth had to be used. Compared to machines of the present-day with corresponding outputs, but many fewer teeth, the earlier pumps were therefore bulky and heavy. These early pumps had also other disadvantages. The clearances were large, so that the slip or leakage was heavy, volumetric efficiency was low, and the pumps were scarcely capable of developing any suction head. Moreover, the influence of the trapping of the fluid, which occurs as the teeth engage, does not seem to have been fully understood, even at a quite recent date, and for many years it led to a quite unnecessarily large increase in the power required to drive the pump.

Since the end of the war the improvement of the gear pump has been rapid, and it is now no longer restricted to those very small capacities with which even to-day it is commonly associated. Modern gear pumps are made in capacities up to about 1000 gallons per minute, and are capable of pumping all kinds of liquids, including highly viscous and corrosive materials. Some of the improvements that have taken place can be traced to improvement in machining methods and some to the cumulative effect of alterations in the general design. But the greater part has occurred largely as a result of a better understanding of the operation of the pump and the consequent development of tooth forms which permit fewer teeth to be used on each wheel and which reduce the deleterious effect of trapping.

In the following notes some examples of modern machines are described, and their historical development traced where the necessary information is available.

1904/25,222: *White and Handoll.*—At the time of taking out this patent Handoll was connected with the Albany Engineering Company, Ltd., and White seems to have joined the firm soon afterwards. The patentees, like many others at about this period, were concerned to reduce the leakage through the clearances over the heads and around the sides of the gear teeth. Ordinary packing such as had been used in the past had been proved unsatisfactory. It was therefore suggested that shallow grooves should be cut along the head and around the sides of each tooth. Liquid gathering in these grooves would then tend to seal the clearances against leakage. No novelty was claimed for the use of such grooves, the effect of which had been known for many years. But their application to the gear pump was new. Curiously enough, it does not seem to have occurred to Handoll and White at this date that similar grooves could be used to limit leakage along and around the shafts, for in a patent taken out in 1908 (No. 7968) cup leather stuffing rings are placed around the shafts for that purpose. Not until 1918 (Patent No. 121,686) did Handoll, now alone, propose that a ring groove should be made at each end of each rotor. The radial grooves along the sides of each tooth were made to engage with it. As will be seen from the drawing, Fig. 35, of a typical modern pump made by the Albany Engineering Company, Ltd., of Ossory Road, London, S.E.1, the construction so proposed has been retained to the present day. Handoll's 1918 patent is of more considerable interest, however, because he proposed that additional grooves should connect the ring groove with each of the spaces between the teeth. He remarks of these grooves that they will obviate "the friction and wear on the pinion bearings, which is apparently caused by the difference between the pressure on one side of the pump and that on the other." But it is, in fact, clear that the grooves could have little, if any, influence on that pressure, and it seems probable that their actual effect was to relieve the high pressures generated between the teeth, when trapping occurred, by laying open a way of escape for the fluid.

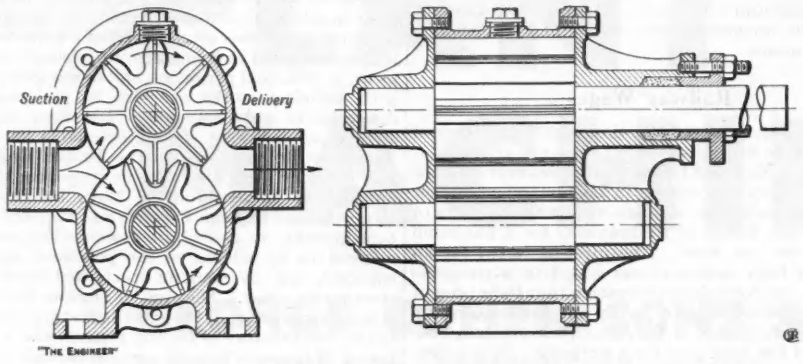


FIG. 35—GEAR PUMP—ALBANY

Modern products of the Albany Engineering Company, Ltd., take a variety of forms to suit the characteristics of liquids as different in density, viscosity, and general character as water, gelatine, massecuite, benzol, bitumen, and oil. In all these pumps, pinions with eight teeth are employed. Normally the casing is made of gunmetal with a steel or bronze shaft, or of cast iron with a steel shaft. But where corrosive material is to be pumped, other metals are employed. Rotor clearances are adjusted to suit the characteristics of the liquid handled. The larger pumps will operate with a suction lift of 20ft., and deliver against heads up to 300ft. Specially designed pumps have been made to deliver against pressures up to 800 lb. per square inch. Small pumps run at 500 or 1000 r.p.m. and give deliveries of 1900 and 1800 gallons per hour respectively. For heavier duties slower speed machines are manufactured, running at 250 r.p.m. and delivering up to 10,000 gallons per hour. For really heavy work, the pumping pinions are partially relieved of load by the addition of back gears external to the pumping chamber. Back-geared machines run at 250 r.p.m., and are made in capacities up to 50,000 gallons per hour.

These gear pumps are used for a variety of purposes, and the arrangement of the casing, shafts, bearings, &c., is altered to suit the particular duty concerned. The engraving, Fig. 36, shows a unit intended particularly for handling foodstuffs, such as wines and spirits. Contamination of the liquid with lubricant from the bearings cannot, of course, be tolerated, and the bearings are thus arranged external to and entirely separate from the pump casing. A pump specially designed to meet the requirements of road tankers is illustrated in Fig. 37. Being used for filling and emptying the tank it is fitted with a reversing gear-box for changing the direction of rotation of the pumping gears and thus reversing the direction of flow of the liquid.

1910/18,058: *G. and J. Weir.*—The gear pump made to this day by G. and J. Weir, Ltd., of Cathcart, Glasgow, for supplying fuel oil for pressure oil-burning systems seems to have been developed from a much earlier machine intended for a totally different service. A patent taken out by the firm in 1910 describes a machine which was to be used as a dry or wet air pump in connection with steam condensing plant. The drawing, Fig. 38, shows the arrangement of the proposed dry air pump. Air drawn in from above at A was delivered into a chamber B surrounding the pump, which was partially filled with water and thus eliminated any possibility of a return leakage of air. The water in the chamber B displaced the air, which escaped at C. This water was then carried out of chamber B and delivered into chamber D below under pressure. It found its way out of that chamber either through a cooler E, whence it was passed into the air suction to cool and increase the density of the vapour,

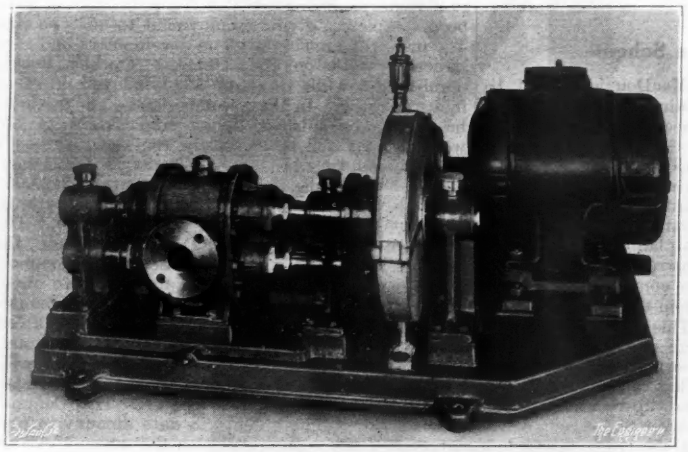


FIG. 36—WINE AND SPIRITS PUMP—ALBANY

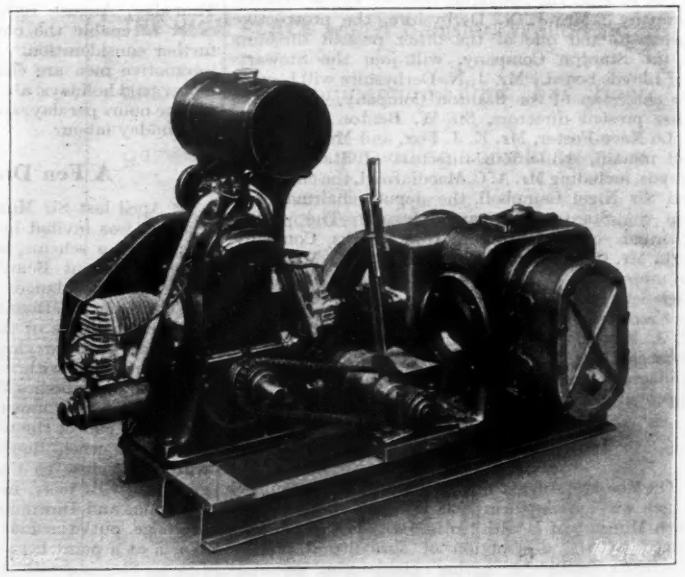


FIG. 37—PUMP FOR ROAD TANKERS—ALBANY

or through a return channel F with a screw-down control valve leading to the upper chamber.

The modern machine is similar to its prototype only in the design of the chambers in which the rotors work, and in the fact that wheels with more numerous teeth than is usual nowadays have been retained. It has a particular interest because a two-stage arrangement is adopted. Oil coming in at the suction branch (Fig. 39) passes through a port D to the first stage wheels, and is delivered through port E directly to the second stage wheels, which discharge it to the outlet branch *vid* passage F. The pump is carried on the side of a cast iron pedestal, upon the top of which the

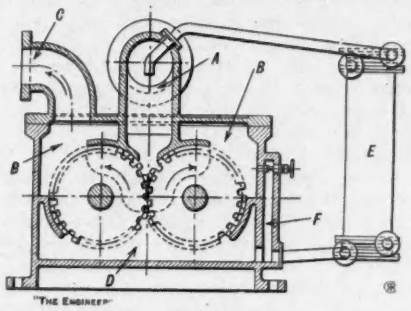


FIG. 38—WEIR—1910

electric driving motor is mounted and arranged to drive the pump through a chain. Single helical gears are used where the operating conditions permit, and are arranged in opposite hand in the two stages to bring about axial balance. Pumps of this kind are made with capacities up to 1630 gallons per hour and delivery pressures up to 200 lb. per square inch.

1925: *David Brown.*—It has already been said that in the earlier gear pumps it was necessary to use pinions with a greater number of teeth than is now usual. The reason lay in the more or less universal use of the involute form of tooth which had been found so very satisfactory for

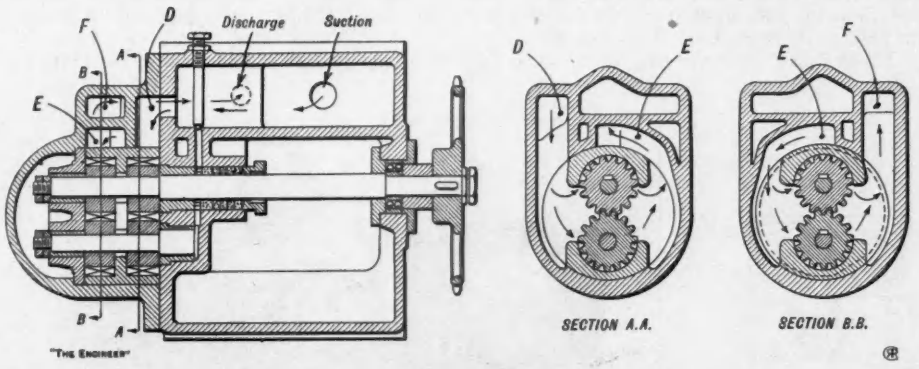


FIG. 39—PUMP FOR FUEL OIL BURNER—WEIR

ordinary gearing applications. This form of tooth does not lend itself to the design of pairs of equal pinions, having a small number of teeth such as are wanted in a gear pump. If, for instance, the ordinary 14½ deg. pressure angle involute tooth is used,

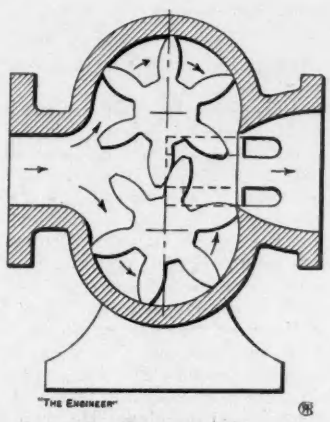


FIG. 40—GEAR PUMP—HAMWORTHY

correct tooth action can only be obtained if there are twenty-six teeth on each wheel, and even with 20 deg. pressure angle the smallest number of teeth is fourteen. The number of teeth can be further reduced by tooth correction, but even then the working of the gears is likely to be unsatisfactory because the distribution of wear is irregular.[1]

In 1925 there was developed by David Brown and Sons (Hudd.), Ltd., of Huddersfield, a form of tooth, known as the "Roloid," which departed from the involute form. It was designed especially for use in gear pumps and enabled the permissible number of teeth to be reduced to seven without adversely affecting the gearing or wearing qualities. By the use of this form of tooth the output of any given size of pump was increased by as much as 100 per cent. in comparison with a machine with involute gears of fourteen teeth each. To-day, the firm manufactures a wide range of "Roloid"

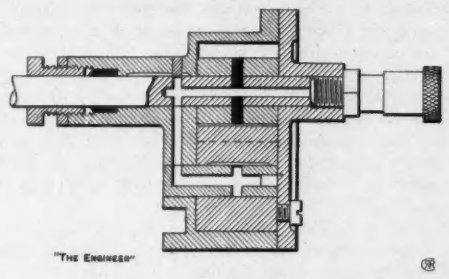


FIG. 41—GEAR PUMP—ROTHERHAM

pumps. The standard pumps are usually given rotors with eight teeth, and are capable of delivering large quantities of fluid at relatively low pressures. These characteristics are particularly suited to the supply of lubricant in forced lubrication and other systems. Other types of gear pump are manufactured to meet differing conditions. Since the introduction of the straightforward "Roloid" pump, a double-helical unit has been developed and will be further described in a later section of this series.

There are many other manufacturers of gear pumps in this country, but lack of space prevents us mentioning more than two more. In the pumps made by the Hamworthy Engineering Company, Ltd., of Poole, passages are formed in the end covers leading to the discharge pipe (Fig. 40). They are provided with the object of relieving the high pressure that may be generated when fluid is trapped between a pair of mating teeth.

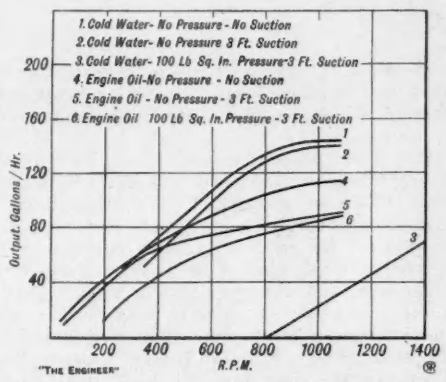


FIG. 42—PERFORMANCE OF PUMP—ROTHERHAM

The impellers of this firm's pumps are notable for having only six teeth each. They are especially cut to gear together satisfactorily. Hamworthy pumps are made in capacities up to 11,500 gallons per hour, and are supplied in a variety of forms, with external bearings, back gears, &c., to suit the different duties for which gear pumps are nowadays used. The design of pumps made by Rotherham and Sons, Ltd., of Coventry, is revealed by the drawing, Fig. 41, in which the means adopted for lubricating the driven pinion, which runs on a fixed shaft, should be noted. The characteristic curves (Fig. 42) show the performance of a pump of this kind when operating with water and oil under various conditions of pressure head and suction. In connection with curves 1 and 2 it should be noted that outputs at speeds above 700 r.p.m. seem to have been limited by the size of the inlet and discharge pipes.

HELICAL GEAR MACHINES

Helical gear machines have the advantages, as was pointed out in article No. XVI of the first part of this series, that if the face width is made equal to a multiple of the axial pitch a theoretically

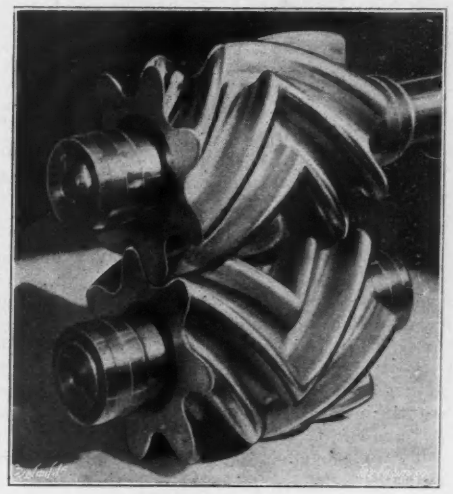


FIG. 43—HELICAL "ROLOID" GEARS—DAVID BROWN

invariable discharge will be obtained; that no trapping can occur, since the fluid moves along the bottom of a tooth space; and that the fluid is not required to move into and out of the tooth spaces through areas which vary in size in accordance with the angular position of the rotors. It is necessary, however, if leakage along a tooth space from the outlet to the inlet side is to be prevented, that there shall be no backlash between the teeth and no bottom clearance. Helical gear machines show to advantage as air motors, since provision can be made for the expansion of the air.

Within recent years David Brown and Sons (Hudd.), Ltd., of Huddersfield, have developed a helical gear pump which has proved very successful and is now used in connection with machine tools, hoists and presses, as a fuel oil pump, and for

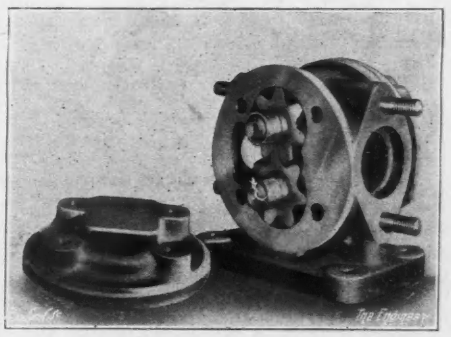


FIG. 44—HELICAL GEAR PUMP—DAVID BROWN

high-pressure lubrication systems. The same mechanism has also been adopted as an hydraulic motor and provides the advantages of uniform torque and no dead points. The teeth of the gears are of the "Roloid" form, used in spur gear designs, and the helix angle is large—Fig. 43. The internal shape of the casing in which the rotors work is such that the sealing surface between the casing and the teeth is also of helical form having substantially the same helix angle as the teeth of the rotors. Two or more teeth maintain a fine-running clearance along this helical band at all times. The remainder of the internal surface of the casing is curved back and provides areas of admission and discharge to the rotors, which in the developed view are triangular. The result is that

[1] For a fuller discussion of this matter reference may be made to articles by Dr. H. E. Merritt which appeared in THE ENGINEER, Vol. CXLVII, February 15th, 1929.

in its passage through the pump the motion of the fluid takes place mainly in an axial direction. One of the advantages of the design is that the period during which any tooth space is exposed for the free entry or exit of the fluid can be made equal to or even greater than half the time required for one revolution. Volumetric efficiencies up to 95 per cent., and even higher are claimed according to the duty and the characteristics of the fluid pumped. "Roloid" helical gear pumps are made in capacities up to 636 gallons per minute nominal (*i.e.*, assuming 100 per cent. volumetric efficiency) at a speed of 1500 r.p.m. Pump bodies are of cast iron and rotors are cut from heat-treated carbon chromium steel and shrunk on to high-tensile nickel-chromium steel shafts. Roller bearings carry the shafts. An accompanying engraving, Fig. 44, illustrates a typical pumping set. The characteristic curves reproduced in Fig. 45 refer to a pump of

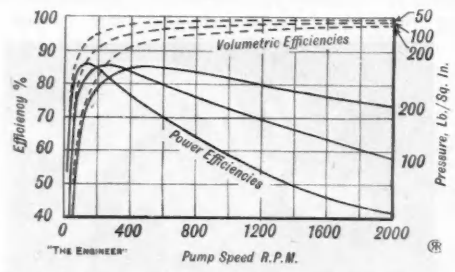


FIG. 45—PERFORMANCE OF PUMP—DAVID BROWN

medium size operating with oil of viscosity 200 seconds Redwood and delivering against pressures of 50, 100 and 200 lb. per square inch respectively. The volumetric efficiency as might be expected rises as the speed is increased. But the overall efficiency after reaching a peak at a comparatively low speed falls away gradually owing to the effect of increasing loss by fluid friction.

Another firm which makes helical gear pumps is Varley Pumps and Engineering, Ltd., of North Acton, London, N.W.10. At the time of writing the range of machines produced is only just about to be introduced to the market. The drawing Fig. 46 shows the arrangement of a typical unit,

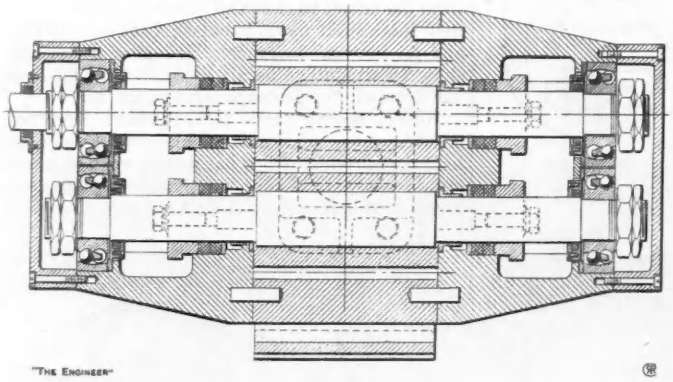


FIG. 46—HELICAL GEAR PUMP—VARLEY

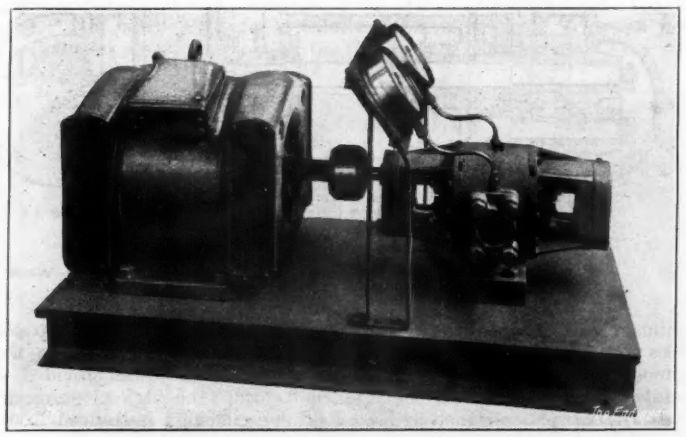


FIG. 47—PUMPING SET—VARLEY

and a photograph reproduced in Fig. 47 gives an impression of the appearance of a set capable of pumping 3600 gallons per hour against a pressure of 175 lb. per square inch. The pump is directly coupled to a 12½ H.P., 1400 r.p.m. motor. The design of these pumps is such that the rotors can be moved axially to adjust for mesh and prevent the end surfaces rubbing on the faces. Nitrided steel is used for the rotors. Pipe connections are formed in the same casting as the feet, so that joints cannot be strained by a pull on the pipes and all parts can be dismantled without disturbing the pipes or the drive.

(To be continued)

NEW INDIAN COAL AND IRON DEPOSITS.—The General Report of the Geological Survey of India for 1938 gives particulars of new deposits of coal and iron ore which have been discovered. It is stated that in one workable seam alone, in the Langrin area in Assam, a total reserve of 80,000,000 tons of coal is indicated, and there are estimated to be 610,000,000 tons of high-grade iron ore in Bastar State, Eastern States Agency.

The Samuda Collection of Literature Relating to Atmospheric Railways

By C. F. DENDY MARSHALL, M.A., M. I. Loco. E.

No. II

(Continued from page 161, August 11th)

THE eighteenth volume is the Report of a Select Committee which had been appointed to inquire into the question of atmospheric railways generally, in consequence of the number of applications which were being made to Parliament for the construction of these lines. The report is dated April 24th, 1845, the time of the beginning of the Railway Mania. It is distinctly in favour of "the general merits of the atmospheric system," but adds cautiously that "experience can alone determine under what circumstances of traffic or of country the preference to either system should be given."

The following are some interesting points brought out in evidence. Joseph Samuda stated that the line from Croydon to Epsom was in progress of execution, and that an extension of it to London had been sanctioned in 1843, and the South Devon Railway, 52 miles in extent, from Plymouth to Exeter, was being also constructed on this principle. He described an ingenious way of obtaining a vacuum quickly, which it was intended to use on the South Devon Railway, namely, pumping water up into a closed reservoir, about 30ft. high, and letting it run out suddenly when required.

Joshua Field* gave evidence in favour, stating that he was making the engines for the Croydon Railway. He mentioned the greater acceleration possible.

The next witness was Brunel, who gave particulars of the line he was constructing in South Devon, which was on the broad gauge, and was only a single line. He believed that travelling could be made much more luxurious and comfortable than on the ordinary railways. He gave ten years as the utmost life of a locomotive.

The Rev. T. R. Robinson, D.D., then gave evidence, in the course of which he recommended what he called "conjugate" (meaning compound) engines, which he said were very common in France.

Bergin was the next witness. From his evidence it appears that the heater did not act exactly as it was intended to do; it only produced a temperature barely warm, that was necessary to prevent the sealing mixture sticking to it, which happened when it was cold. If the train stood still, and the composition became heated up, they had to send a man to relay it. He made the interesting observation that certain sudden checks in speed occurred in passing under bridges. They were due, of course, to the "packing up" of the envelope of air carried along by the train. Considerations of economy in working would induce them to send light trains in quick succession, whereas on a locomotive line it paid better to have heavy trains and work the engines to their full capacity. Another item of interest is that there is one particular point at which the resistance of the air pump is at a maximum, up to which each successive stroke increases in resistance, and beyond which it decreases. This point on the Dalkey pump was 22in. of mercury. This effect is not easy to explain. Could it be due to a deformation of the pump piston? On the Dublin and Kingstown Railway nearly 25 per cent. of the passengers were "subscribers"—otherwise season ticket holders.

Charles Vignoles was strongly in favour of the atmospheric system. He had recommended it for a line between Vienna and Schönbrunn. Although not prepared to use it indiscriminately, he would do so under most circumstances. He laid down two principles; that the load is as the diameter of the pipe and the degree of rarification, and that the velocity is as the proportion between the areas of the air pump and vacuum pipe, and is totally independent of the load. The velocity is the same with all loads, and with all inclinations (saving certain practical deductions). These propositions are rather of the "tall" order.

Robert Stephenson was then examined. He gave it as his opinion that the cost of producing a certain amount of power was very much the same with locomotives, with stationary engines and ropes, and on the atmospheric principle. He considered the loss due to the friction and weight of 1 mile of double rope equal to that caused by leakage in 1½ miles of atmospheric pipe. He said the longitudinal valve on the Dalkey line was "a complete triumph of mechanism." He gave the atmospheric resistance to the piston of a locomotive as nearly 40 per cent. of the power.

William Cubitt, who was the engineer for the Croydon Railway, had recommended an atmospheric line from London to Portsmouth. Locke and Bidder were not in favour of the atmospheric system.

Volume 19 is a translation of a report by Arago on "The Atmospheric Railway System, and on the Proposed Atmospheric Railway at Paris, Seven and a Half Miles Long." It is dated September, 1844. He says that Clegg and Samuda's first experiments were made at Chaillot, in 1838, before the line at Wormwood Scrubbs. After giving an account of the longitudinal valve used in England, he describes one invented by his fellow-countryman, Hallette, in which the slot was kept tight by two inflated tubes "of thick and close-woven material," between which the connecting piece passed. The arrangement sounds to be liable to serious wear and tear, and does not seem to have been adopted. He then describes the invention of Pecqueur, who suggested a compressed air locomotive, drawing air from a tube laid between the rails. Pinkus had proposed a somewhat similar scheme, but using a vacuum instead of pressure. The report recommends that an experimental line should be constructed.

Volume 20 is a copy in the original French of

* He was asked if he was a manufacturer of locomotive engines, to which he replied, "Yes, but we have not made many."—C.F.D.M.

Mallet's report, the translation of which has already been mentioned.

The twenty-first is a formidable tome of over 1000 pages, being a manuscript copy of the evidence on the Northumberland Railway Bill (May, 1845), which was projected on the atmospheric principle.

Joseph Samuda was the first witness, and stated that his preliminary experiments were made at their works, and secondly at Wormwood Scrubbs (without mentioning Chaillot). He gave the loss from leakage as equivalent to 5 H.P. per mile at the most economical rate of working, which was 15in. or 16in. of mercury. At higher rates of exhaustion, though the amount of air that entered the tube remained much the same, it occupied more volume, and required more strokes of the pump to extract it. The Northumberland line was to run from Newcastle to Berwick, a distance of 64 miles, a single road with engines at intervals of 3 to 4 miles. Near Berwick there was to be an incline of 1 in 59. Samuda said that he had seen a train pulled up by the wind on the Dublin and Kingstown Railway (which was worked by locomotives).

Brunel was the engineer for the Northumberland Railway. He stated that on the South Devon Railway there were 10 miles of 1 in 40 to 1 in 50. He made a very interesting reply to a question on the subject of side winds, showing that he did not believe in the then accepted explanation of their action, namely, flange pressure, but attributed it to the large volume of air deflected, which has been shown to be correct.

George Hudson, the Railway King, was also examined, principally on the question of traffic.

The next witness was Robert Stephenson, whose evidence on the subject of air resistance runs to many pages. He was given a good deal of trouble over the accepted method of measuring it in pounds per ton, being confronted with the case of two carriages, one loaded with lead, and the other with feathers. He did not think any substantial improvement could be made to the longitudinal valve, saying that the whole leakage on the Kingstown line only amounted to about what would occur with a hole ¾in. diameter—which is a remarkable testimony to its efficiency. He said that his latest locomotives were capable of moving about 800 tons at about 10 miles an hour, and were of 200 to 300 H.P.

Bidder gave some interesting evidence on the subject of the friction of the air in the tube. In his opinion only one minute would be saved by the elevated tanks proposed by Brunel.

Thomas Hawkesley was also examined about the friction of fluids in pipes, a subject on which he was a recognised authority. He said that the nature of the material of which the pipe was constructed did not make much difference in the case of a gas, because the particles next the pipe are more or less stagnant, and the velocity is greatest at the centre; the resistance is caused largely by the motion of the particles among themselves.

Scott Russell followed, and described some experiments he had made by allowing carriages to coast down an incline. First-class carriages, he said, weighed very nearly 4 tons. According to him, the friction was constant, but the other resistances, "be what they may," increased at a considerably higher ratio than that of the square of the velocity.

Locke, again, said he did not believe in the atmospheric system, which he thought would be more expensive. He said a train with a locomotive cost under 1s. a mile to run, including all repairs, superintendence, enginemen's wages, coke, and oil. He was the engineer to the South-Western, which had just opened a branch from Woking to Guildford, and was seeking powers to push it on to Portsmouth, being therefore a rival to the proposed atmospheric line to that place.

The Bill was lost.

Volume 22 is another large manuscript book, containing the evidence on the "London and Portsmouth (Direct) Railway Bill."

The first witness was Joseph Cubitt, examined on June 9th, 1845. It was to go by Epsom, Leatherhead, Dorking, and Godalming; thence close to the present South-Western route.

William Cubitt was also examined at great length. He was the chief engineer, Joseph, his son, being the "acting" engineer. The stations, where possible, were to be arranged at the top of an incline, to facilitate starting and stopping, as is done on some of the tubes to-day. If carriages were required to be moved by themselves, they were to be pushed by hand. He said the London and Birmingham stations have nothing but porters to push the trains about. At some places horses were used. It was thought dangerous to have engines shunting in the stations.

B. D. Gibbon, the engineer of the Dalkey line (also of the Dublin and Kingstown), mentioned the interesting fact that at the Dublin end of the pipe the first stroke of the engine at Dalkey could be heard, which was the signal to prepare to start the trains. The barometer also moved instantly. Not only he, but other engineers at that time evidently thought that the best way of stopping was to skid the wheels.

Brunel was asked whether the atmospheric and locomotive systems could be worked in conjunction, and replied that they could, and that he thought it very likely he would apply the atmospheric as an assistant power on an inclined plane worked by locomotives. He stated that with an express train half the power was absorbed by the engine.†

Robert Stephenson said that the average passenger trains all over the country weighed 40 to 50 tons. He gave a rather amusing answer when counsel said, "I suppose you can have little doubt it would tend to the convenience of the public if the third-class passengers had the same facility as the first?" The reply was, "I should rather doubt that. They do not like to go at 40 miles an hour." He was also questioned as to the possibility of combining the systems, and said that he had considered it would be feasible on a line that he had charge of, from Tring to Staffordshire, which had just been rejected by Parliament. The atmospheric system was to have been applied as an auxiliary on a section of 5 miles.

Locke gave the expenses of working trains on the South-Western, Grand Junction, and London and Birmingham railways as from 11d. to 1s. 0½d. per mile, whereas five years earlier it had been 16d. or 17d. The cost of new engines on the South Western was £1700 or £1800, with tender.

Volume 23 contains evidence given on the "South-Eastern, Hungerford Bridge to Chilham Railway, with Branches," June 14th, 1845. The same old ground is gone over every time, with the same witnesses, on these railway Bills, the waste of time and expense being appalling.

Bidder made the remark that the cost of a locomotive—meaning, of course, running cost—is two-thirds of the cost of post horses per mile.

There is also some evidence on the London and Croydon, Chatham and Gravesend Railway Bill. For practical purposes this appears to be the same thing under another name. They were proposing gradients of 1 in 50.

Samuda mentioned the experiments in France to which Arago had alluded, calling them only model experiments, the first full-scale trial having taken place at Wormwood Scrubbs. He said that the experiments in his works were with a tube about the diameter of a tumbler, and that they drew thirteen people and 13 cwt. of iron up 1 in 30.

The twenty-fourth (and last) volume of the Samuda collection consists of a paper on "The Peculiar Features of the Atmospheric Railway System," read by George Berkeley at the Institution of Civil Engineers on April 15th, 1845. The paper is rather severely critical. A number of eminent engineers took part in the discussion—some for and some against—but there is nothing of any particular interest at the present day. A remark by Nicholas Wood is an exception, being to the effect that one of the earliest locomotive engines, made by Stephenson for the Darlington Railway, was now conveying coals at a less cost per ton than on any other railway in England.

Three further volumes have been added to the collection. One is a small book called "A Popular Sketch of the Various Proposed Systems of Atmospheric Railways," by William Jones, published in 1845. It contains a description of Pilbrow's patent, which dispensed with the longitudinal valve. Instead, both the carriage and the piston carried racks, 30ft. long. About every 25ft. there were vertical shafts with pinions at the top outside the tube, and below, inside; the pinions engaging with the respective racks. A still more costly arrangement was to have spiral threads and worms.

Another addition is a little book describing the Paris–St. Germain Railway, by C. Etienne, published at Paris in 1846, with two very interesting plans. The atmospheric portion started at a place called Nanterre, 7½ miles from Paris, and went to St. Germain, a distance of 5½ miles, the last 1½ miles being for the most part on a gradient of 1 in 28½, and a curve of 20 chains radius. On the steep part the tube was the largest ever employed, namely, just under 25in. diameter. The Hallette valve, with pneumatic lips, was not used, as the drawings in this book show a flap valve.

The third addition is an "Address to the Proprietors of the South Devon Railway," by the chairman, published in 1848. The directors had virtually decided to abandon the atmospheric system, against the wishes of the chairman. At all events, they had resolved to suspend the atmospheric working "until the same shall be made efficient at the expense of the patentees." The chairman believed that it could be made satisfactory, and stated that giving it up would involve a loss of £300,000, and a large additional expense for locomotives, &c.

In an appendix there is a report by Brunel to the directors, dated August 19th, 1844, in which he took on himself the full responsibility of recommending the adoption of the system. He estimated that there would be a saving in the first outlay of £60,000, and on the working of £8000 a year. Then follows an extract from another report by the same, dated February 29th, 1848, which was still hopeful, and pointed out that great expense was being incurred owing to the electric telegraph not being completed, which made it necessary to keep the engines working almost continuously, whether wanted or not. A third report was made on August 19th, 1848. In this he says that the engines were unsatisfactory and unnecessarily extravagant; that the leather of the valve cracked in dry weather and required replacing. He did not recommend the extension of the system beyond Newton Abbot, as the cost of construction and difficulties of working were so much greater than had been anticipated. With regard to the section between Exeter and Newton, he said that the whole of the valve must be renewed by Mr. Samuda, and alterations made to the engines.

There is also a letter from Samuda on the subject. He proposed that the company should pay for the new valve, and that he should be responsible for its upkeep for twelve months.

Details of the cost of running the various engines follow. The system was shortly afterwards abandoned. Some of the tubes were employed for a drain. "To what base uses we may return!"

Two more recent additions may be mentioned, an article on "Pneumatic Transmission," by F. C. Danvers, in the *Quarterly Journal of Science* for 1871, and a paper by Sir Frederick Bramwell on "The South Devon Atmospheric Railway," reprinted from "Proceedings," Institution of Civil Engineers, 1899.

Considering the obvious difficulty of maintaining a satisfactory air-tight communication between the train and the piston, it is rather surprising how nearly the atmospheric system succeeded in "making good."

Altogether, there were four cases of its application. The first was from Dublin to Dalkey, which operated from 1843 to 1855 quite satisfactorily, the chief reason for its abandonment being an extension to Bray, which was to be worked by locomotives, and the inconvenience of having a portion in the middle of the line from Dublin to Bray, on a different system. There must, however, have been good reasons for not extending it, as was at first proposed.

The second was from Forest Hill to Croydon, a distance of 5½ miles, which was opened in the latter part of 1845, and extended northward to New Cross in January, 1847. The line was then sold to the Brighton Company, who abolished the system, giving as a reason that it had insufficient power to deal with the Epsom race traffic. Here, again, the inconvenience of having a section connected with locomotive lines at both ends came in. With reference to this line, it may be mentioned that a prospectus of the "Dorking, Brighton, and Arundel Atmospheric Railway," dated in September, 1845 (capital one million pounds), stated that "if any doubt has hitherto existed as to the efficiency of this principle, that doubt has been most satisfactorily removed by the recent trials on the Croydon Railway, the results of which have exceeded the most sanguine anticipations, and prove that railways constructed on the atmospheric principle must eventually supersede all others."

The third example was the Paris and St. Germain Railway, which was opened in 1847, and worked with great regularity for about six years, when the traffic became so dense that the power of the engines was insufficient to cope with it. Nevertheless, the line struggled on until 1860; during the whole period of nearly fourteen years there was no accident, nor suspension of the service;

† Modern improvements have reduced the proportion to a third, or less.—C.F.D.M.

but at last it became obvious that a complete reconstruction was necessary to deal with the traffic, and the improvements that had come about with locomotives which rendered them capable of hauling trains up the inclines led the directors to decide upon the abandonment of the system.

The last instance was the South Devon Railway, opened from Exeter to Newton Abbot, a distance of 20 miles, in January, 1848, and abandoned at the end of the year, for reasons already given. This line was the least successful of them all and never seems to have worked satisfactorily.

On the whole, it cannot be said that the principle did not have a fair trial, and no one is ever likely to try it again. The other method of atmospheric working, namely, enclosing the whole train in a tunnel, has never been given a chance to show what it could do, and it may be remarked that by this system high-speed locomotion is available for about half the power required by any other.‡

Rigid Concrete Pontoon Bridge

By E. E. R. TRATMAN

No. II

(*Continued from page 156, August 11th*)

WHILE the long floating bridge or pontoon structure already described is of great interest in itself, the arrangement for the opening and closing of the 202ft. navigable channel merits particular attention.

The Movable Pontoon

It will be seen from the plan and side elevation in Fig. 5 that this opening arrangement includes the four pontoons, Nos. 16, 17, 18, and 19, whose arrangement is shown in Fig. 1 *ante*. Pontoon No. 16 is Y shaped in plan, its open portion forming the end of the dock or slip into which the movable span on the rear end of No. 18, when it is in position for road traffic. The diversion is made by easy curves of 400ft. to 1763ft. radius, with suitable super-elevation.

The pontoons forming the dock are essentially similar to the others, but vary in details on account of the difference in widths, and the provisions for hauling, guiding, and locking the movable pontoon. One of the drawings, a section of the side pontoon, No. 17-L, shows one pair of the transverse steel trusses which connect it with 17-R. These trusses, 10ft. deep, are fastened to the bottom of the pontoon by 3¼in. vertical rods, about 20ft. long, having the

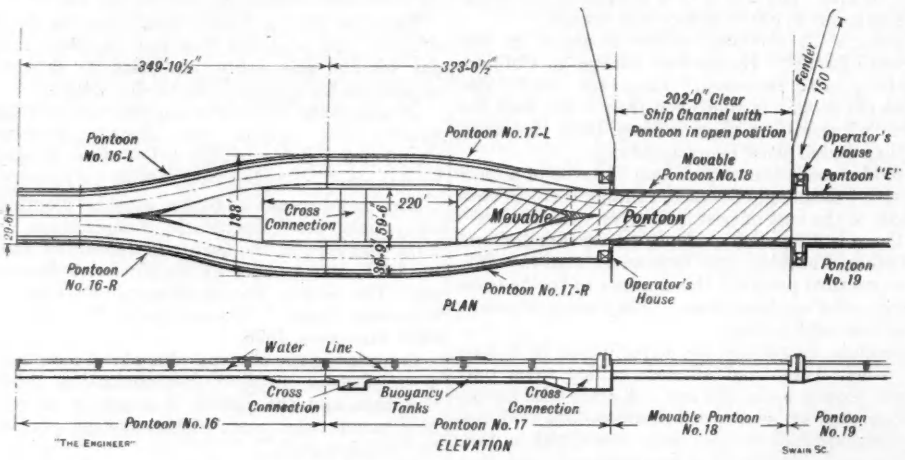


FIG. 5—MOVABLE PONTOON FOR NAVIGABLE CHANNEL

is moved or telescoped. It is also deeper than the others, 17ft. 6in. instead of 14ft. 6in. This pontoon is made in two separate parts, each forming half of the stem and one arm of the yoke or Y. In the stem the contact faces of the two parts are bolted together, in much the same way as the ends of adjacent pontoons, already described—see Fig. 2 *ante*. But in this side connection, as shown in the drawings on the opposite page, the contact walls are thickened on the inside, and through these ribs are passed 2in. bolts in 2½in. pipe sleeves. The shear keys here are of steel, instead of concrete. It will be seen that each shear key is a piece of 20in. rolled steel joist passing through both walls and fitted in each wall between two 12in. steel joists above it, and two 15in. steel joists beneath it.

Pontoon No. 17 consists of two separate parallel pontoons—17-R and 17-L—forming the sides of the dock or slip, which provides a travel of 220ft. for the movable span. And the heel or rear end of this latter pontoon—No. 18—is always held between the side pontoons, Nos. 17-R and 17-L. For stability these two parts are connected at each end by a pair of transverse steel trusses secured beneath the pontoons.

The movable pontoon, No. 18, is 59ft. wide, 378ft. long, and 14ft. 6in. deep. As stated, its rear end lies permanently in the dock formed by the side pontoons, with about 3in. clearance on each side. Pontoon No. 19 is the abutting fixed span to which the movable pontoon is locked—end to end—when the navigable channel is closed and the road is open to traffic. It will be seen by the plan, Fig. 5, that the 45ft. four-lane roadway on the main part of the bridge divides on pontoon No. 16, each side having a two-lane, 24ft. roadway and a single sidewalk. They come together again

threaded ends upset to 4in. In the pontoon, these bolts lie within 6in. pipe sleeves built into concrete posts or pedestals formed integrally with the bottom of the pontoon. In the trusses the rods pass through hollow posts formed of pairs of 8in. by 8in. angles welded together.

These trusses have single angles 8in. by 8in. for the chords or booms, double angles, 8in. by 8in. for the posts, except where the welded hollow posts are used, and single angles 8in. by 6in. for the diagonals or web members. Cross frames or sway braces are provided at intervals, as well as top and bottom lateral diagonal bracing over the booms or chords.

For additional buoyancy in this part of the bridge rectangular welded steel tanks are secured under the entire length of Nos. 17-R and 17-L, and also under the ends of the pontoons, Nos. 16 and 19. The typical arrangement is shown in the drawings. The tanks are mainly units, 12ft. by 40ft. and 5ft. deep, secured by long vertical rods or bolts in an arrangement very similar to that for the attachment of the steel trusses. The bolts are 1½in. in diameter, and pass through pipe sleeves welded into the tanks. Provision is made for blowing out the tanks by means of 1¼in. water pipes and ¾in. pipes for compressed air fitted with couplings for attaching hose. These buoyancy tanks and the transverse steel trusses, all of which are permanently submerged, are given a primer coat and two finishing coats of Inertol paint.

Machinery for operating the movable span is mounted in a room under the deck of the stem portion of the Y-shaped pontoon which forms the end of the dock or slip. This machinery is in duplicate, each with a motor-driven cable drum,

‡ See THE ENGINEER, page 524, May 13th, 1932.

54in. in diameter, for a 1½in. hauling cable. There are two cable haulage systems, one for opening and the other for closing, the cables being led over guide sheaves along the inner sides of pontoons Nos. 16 and 17 to attachments on the movable span No. 18.

To guide this pontoon when moving it is fitted on each side with vertical and horizontal cast steel rollers, which ride on track plates in longitudinal recesses along the sides of the flanking pontoons. These recesses, shown in the drawings, are about 36in. high and 24in. wide. The vertical guide rollers are 36in. in diameter and 12ft. wide on the face. Each roller is carried by a roller bearing on a stub shaft or journal, 10in. in diameter and 14in. long, mounted at the end of a radial frame about 15ft. long. This frame is pivoted at its opposite end on a 4½in. pin, in order to allow for a limited vertical movement between the two pontoons. The horizontal rollers are 48in. in diameter and 12in. wide and are mounted in a similar way, except that the radial frames permit a slight horizontal play.

The top, bottom, and side of the roller recesses in the fixed pontoons are faced with 2in. by 14in. steel plates welded to chairs or supports embedded in the concrete. Wearing plates or track plates, ½in. thick, upon which the rollers ride, are welded to the heavier back plates.

For centring the movable pontoon into exact position as it closes against the fixed pontoon, No. 19, the latter is fitted with mechanism that can be projected in front to enter three tapering rectangular recesses or pockets in the end wall of No. 18. Two of these devices are for vertical centring, each with an 8in. hydraulic cylinder, 4ft. 8in. long, the piston rod of which thrusts forward a centring beam composed of a pair of 27in. rolled steel joists, 14ft. long. This beam carries at its outer end a 27in. cast steel roller which rides on plates lining the recess in No. 18. The horizontal centring device, placed in the centre line of the bridge, is very similar, and has an 8in. cylinder, 5ft. 4in. long, but the 15ft. centring beam carries at its end an 11in. locking roller as well as a 27in. guide roller. These devices are also shown in the drawings reproduced.

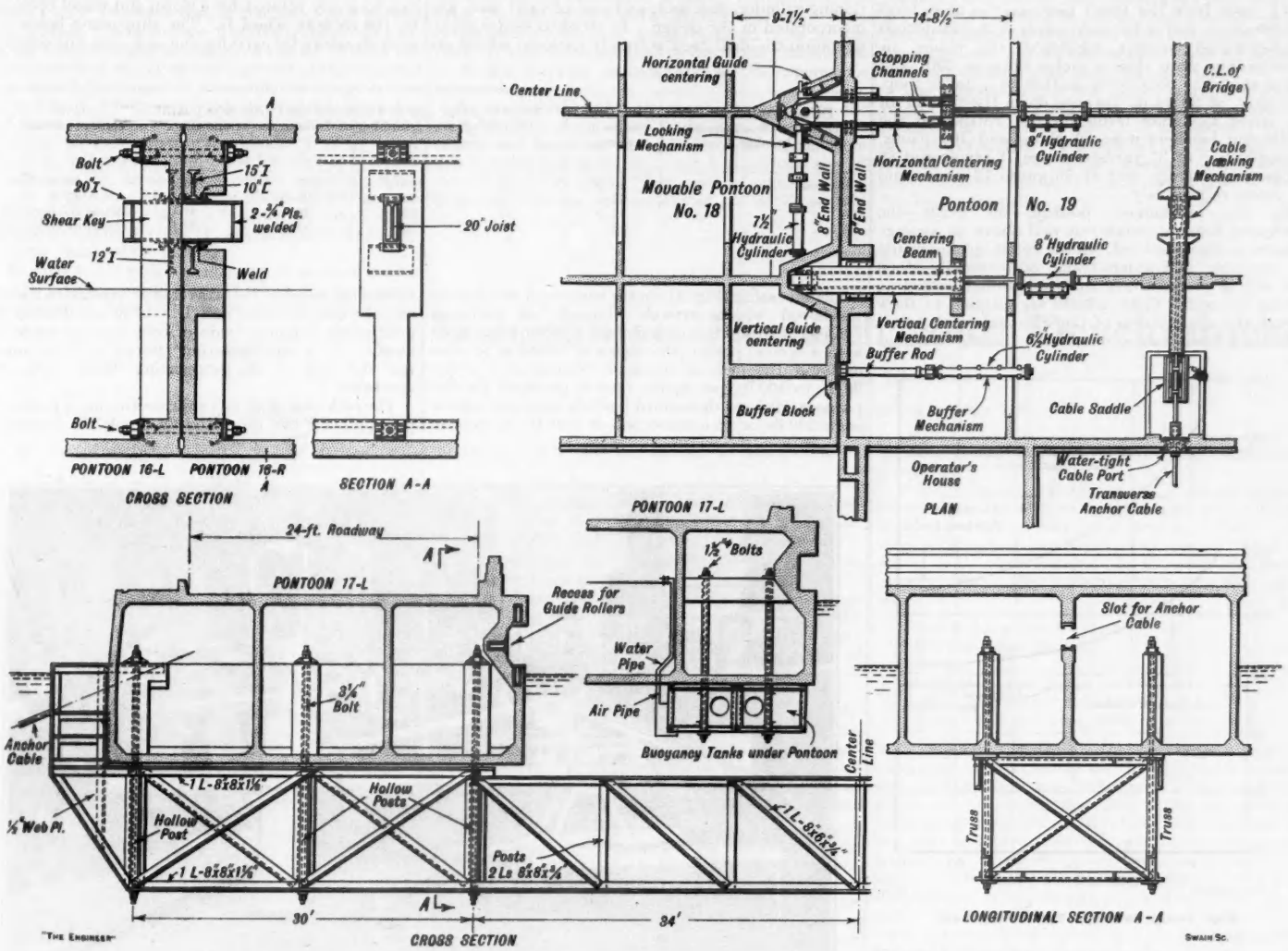
Hydraulic buffers are also fitted to pontoon No. 19 to check the travel of the moving pontoon as it comes to the closed position. Each of the two buffers has a 6½in. plunger, 16ft. 6in. long, moving in a cylinder 8ft. long and having a travel of 6ft. 8in. To engage the heads of these buffer plungers the end face of the moving pontoon has embedded in the concrete two striking plates, ½in. thick and 48in. by 30in. in size. Similar buffers are fitted to pontoon No. 16 at the rear of the dock.

Finally, when stationary and in position, the moving pontoon is locked to the adjacent pontoon, No. 19, by a horizontal transverse bolt lock. The locking bolt or rod is the extension of the piston rod of a 7½in. hydraulic cylinder, 46in. long. The locking mechanism is mounted in the forward end of the moving pontoon and the lock rod extends through the middle pocket to engage the head of the horizontal centring device. The arrangement of this centring, buffing and locking mechanism is shown on the opposite page.

For lighting the roadway at night sodium units will be used, and the kerb lines of the curved roadways at the draw span will be outlined by red "cats-eye" reflecting buttons. Highway traffic will be protected at the draw span by target and lamp signals, gates and yielding barriers. Warning signals are to consist of flashing neon signs with the word "Stop," mounted in a steel case, 24in. square, and fitted to a rotating arm in such a way as to show against traffic when the arm is swung out and to be concealed when it is swung back. These signals will flash thirty to sixty times per minute, and will be supplemented by audible signals consisting of bells or sirens. Roadway blinker lights will be arranged at each end of the moving pontoon and the ends of adjacent fixed pontoons. Pier lamps on the guide fenders of the channel, and the navigation lights at the channel will be in accordance with the regulations of the United States Lighthouse Bureau.

The yielding barriers on the roadway represent a rather novel type of protection which has been applied in a few cases to stop vehicles which are carelessly or accidentally driven past the "stop" signals. As used on this bridge, each barrier is to consist of a pair of steel cable nets mounted on arms pivoted at each side of the bridge, so as to be swung across the roadway and locked together at the middle. The nets are supported by a system of cables on drums and so arranged that when subjected to pressure the cables will

DETAILS OF MOVABLE PONTOON FOR PONTOON BRIDGE



pay out under the resistance of brake action. The barrier and its operating mechanism is proportioned for stopping a 10-ton motor lorry travelling at a speed of 30 miles an hour in a distance of 25ft. Red lights will be mounted on the barriers and the traffic gates.

For operation, the signals, gates, and barriers, and the end lock and operating machinery of the moving pontoon are all so interlocked that they can be operated only in proper sequence. Thus, the warning signals must be displayed before the gates can be closed, and the gates closed before the yielding barriers are closed. Not until then can the end lock be withdrawn, automatically establishing the control circuit for the operating machinery. When the movable span has moved back about 10ft., the centring devices are withdrawn automatically. As it nears the open position, power is shut off and the brakes are applied on the drums of the hauling cables. After an interval to allow the pontoon to come to rest, the control circuit can again be set up to complete the travel, the power being then cut off, brakes applied, and navigation lights changed from red to green.

In the preliminary design, comparisons were made between wood, steel, and reinforced concrete for the pontoons, on the basis of water-tightness, weight, first cost, and maintenance expense. Dead weight was an advantage in resistance to waves, and in deep immersion which would result in a large volume of still water on the lee side to oppose wind and wave pressure on the windward side. In order to determine the action of winds and waves upon the floating structure, a concrete barge, 114ft. long, 34ft. wide, and 10ft. deep, was anchored at the site for several months, records being kept of the tension on the anchor cables and of the pitching and heeling movements of the deck level. No severe storms occurred during this period of observation, and wind velocities did not exceed 40 miles an hour; but even under these conditions the movements were less than had been expected from calculation, and were such as could be permitted easily in the larger permanent structure.

While the depth of water in Lake Washington is sufficient to involve prohibitive cost for a bridge with piers, there is no current, ice, or drift, and by means of the locks the lake level is maintained within a maximum range of 3ft. The lake is 20 miles long, but is narrow, and the pontoon bridge crosses eastward to an island beyond which a fixed bridge crosses a narrow arm of the lake to the mainland. Westward from the pontoon bridge there is a viaduct ending at twin tunnels, 1525ft. long, beyond which the new road leads directly to the central part of the City of Seattle.

This bridge will be operated as a toll bridge to provide funds for operation and maintenance and to retire the bonds issued for construction. It is being built by the Washington Toll Bridge Authority, the plans having been prepared by the Highway Department of the State of Washington. The chief engineer of the Authority is Mr. Lacey V. Murrow, who is also Director of Highways for the State, and the bridge engineer is Mr. Clark H. Eldridge, who also holds the same position in the Highway Department. A special board of consulting engineers is composed of Charles E. Andrews (who was bridge engineer of the San Francisco and Oakland Bay Bridge), Admiral L. E. Gregory (of the Civil Engineer Corps in the United States Navy), Mr. R. B. McMinn, and Mr. R. H. Thomson.

Quiet Concrete Breaker

RECENTLY we were present at the trials in Park Lane, London, of a new design of concrete breaker, which is a distinct departure from any type hitherto produced and possesses several novel features, one of the most important being a considerable reduction in the noise of operation. The new machine, described and illustrated below, is the invention of Mr. Walter R. Pettit, M.I. Mech E., consulting engineer, of 36, Victoria Street, Westminster, London, S.W.1, and is at present in course of manufacture at the works of Howard Pneumatic Engineering Company, Ltd., of Eastbourne.

This power-operated concrete breaker has been primarily designed to reduce the level of the noise which in unsilenced machines has become a public nuisance. We are informed that it was comparatively simple to lessen the noise caused by the exhaust air of the drill, but the main problem was how to reduce the noise produced by the pick. This component is driven by a piston making about 1000 blows per minute and produces high-frequency sound waves which are exceedingly irritating. At the same time, it was desired not to impair the efficiency of the breaker. It is claimed that the Pettit breaker provides the best solution by entirely enclosing the drill within an insulated casing extending right down to the face of the concrete. To achieve these results the machine must be heavier than the conventional hand-operated breaker, and consequently the design provides a more powerful breaker with a power-operated arrangement for controlling and manœuvring it. This construction enables another important advantage to be gained, namely, that the operator is relieved of the bodily and nervous fatigue which is inseparable from working with a hand-operated machine.

Test Results

Summarised below and shown in the graph reproduced in Fig. 1 are the results of some tests carried out by Mr. Charles W. Glover, M. Inst. C.E., acoustical consultant, at the firm's works. The tests were performed with the machine operating on a slab of concrete about 10ft. by 20ft., and 12in. thick, of 4–2–1 mix, matured for over six months. The slab was situated in the open between two workshops some 30ft. apart, and the conditions simulated those of a narrow street with low buildings on each side. Around the corner formed by one of the workshops, 22 yards away, was placed a standard design of compressor unit, of which the receiver pressure was set to 110 lb. per square inch. A survey was then made with a standard noise meter, and at the same time readings were taken of the time taken to pene-

trate the slab. Similar readings were taken for a standard unsilenced hand-operated breaker.

As shown in the graph, the average background noise level was 68 phons, in the works. At a distance of 5½ yards from the Pettit machine the noise level was 90 phons, and at the same distance the unsilenced hand-operated breaker registered 117 phons, or considerably more than a motor horn at 20ft. and about the same noise level as that of a boiler shop. Similarly, at 20 yards distance down the middle of the street the noise levels for the Pettit and the unsilenced breakers were 80 phons and 100 phons, respectively; at 37 yards distance 73 phons and 88 phons, respectively, and at 56 yards 72 phons and 83 phons, respectively.

In the last-named position—56 yards—the unsilenced breaker stands out well above an average London traffic noise level, but the Pettit breaker would be inaudible in London traffic and actually stood out only 4 phons above the background subsisting during the test. These results are claimed to show clearly the effectiveness of the silencing employed.

Further tests were conducted taking readings

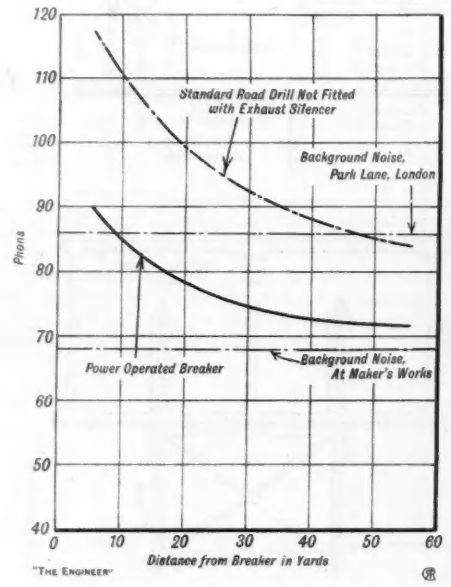


FIG. 1—ACOUSTICAL TEST RESULTS

in an adjoining drawing office 10 yards from the breakers, giving the following results :—

	Loudness in phons. Window closed.	Window open.
Background	58	61
With compressor	64	67
Power-operated machine ...	67–68	71–72
Unsilenced breaker	79	83

With regard to the performance of the breakers, the following observations were made, with an air pressure of 100 lb. per square inch :—

Power-operated silenced breaker.		Hand-operated unsilenced breaker.	
12in. penetration.	Withdrawal.	11in. penetration.	Withdrawal.
Sec.	Sec.	Sec.	Sec.
5	1	15	1
9	1	20	1
10	1	23	1
12	1	15	120
Average 9	1	18	Liable to wedge
Movement to new position : 5 sec.		Movement to new position : 5 sec.	

The above results indicate that the Pettit breaker has more than double the capacity of the unsilenced hand-operated breaker. Moreover, the hand-operated machine is liable to jamb in the concrete and cause considerable delay, but the power-operated machine is withdrawn under pneumatic pressure.

To obtain a reliable comparison it would, however, be necessary for trials to be made over a full working day, the cube of concrete broken up being measured against the expenditure of time, labour, and pneumatic energy.

Since the tests given above were carried out, other tests, at which we were present, as mentioned earlier in this article, have been made in Park Lane, London. Here the background noise ranged from 87 phons to 91 phons, depending on the amount of traffic passing by and the proximity of the recording instruments to the air compressor. The table below shows the results of these tests, comparing the Pettit machine with one and more than one standard breaker fitted with silencers. It can be seen that at a distance of 15 yards the Pettit breaker registered only ½ phon above the background level, and beyond this distance the noise was not recorded because it was below the background noise level.

Distance of recording instrument from concrete breaker.	Background noise in phons.	Noise in phons of 1 to 4 ordinary road drills fitted with exhaust silencer; number of drills in use at one time.				"Quiet" concrete breaker.
		1.	2.	3.	4.	
6 yards	90·0	103	104·5	105	106	92·5
15 ,, ...	87·0	94	95	98·5	100	87·4
25 ,, ...	87·0	91	93	96	97	Below background;
35 ,, ...	86	90	92	93	93	therefore no reading

CONSTRUCTION OF MACHINE

The construction of the machine is clearly indicated in the accompanying half-tone engraving, Fig. 2, and in the drawings, Figs. 3 and 4, showing a general view of the breaker and a section through the drilling component, respectively. Six principal parts, namely, the chassis, turntable, support beam, positioning cylinder, pick unit, and control valve unit, are incorporated in the design. In order to secure silent operation the drill itself is totally enclosed within an insulated casing (Fig. 4), and is connected to a hollow piston-rod which extends through an extractor cylinder. Inside this cylinder the piston-rod is fitted with a special piston, the object of which is to raise or lower the pick as required. Compressed air at 90 lb. to 100 lb. per square inch is provided for this purpose, giving a downward load on the pick point of some 200 lb. or an upward pull of 1500 lb. in order to extract the pick from the concrete should it become jambed therein.

The drill with its insulated casing is carried on a trolley provided with four wheels and it can be moved along a carrying jib by means of an arrangement of wire cables and winding drums. The jib, which is balanced, is supported on a frame, the lower part of which forms a turntable, provided with worm reduction gear for revolving the jib through a complete circle. As shown in Figs. 2 and 3, the entire machine is carried on a chassis fitted with three rubber-tyred wheels, which enables it readily to be moved to any desired position. At the balance weight end of the jib there is an air-operated cylinder for raising and lowering the jib and pick unit.

Referring to the drawings, the chassis consists of a fabricated steel base upon which are mounted the three trolley wheels. The rear trolley wheel is of the castor type, provided with ball bearings. The turntable, also of fabricated construction, is mounted on a central shaft carried on the chassis and is provided with a series of rollers within the casing A, so that it can be easily rotated by a worm and wheel operated by the capstan wheel B. The supporting beam is a steel structure for carrying the pick unit, the counterbalancing weight, the traversing capstan wheel C, and the control valve unit D. At E is indicated the positioning cylinder made of cast iron, operated by means of a double-acting piston and connecting the end of the supporting beam with the turntable.

The pick unit (Fig. 4) comprises two main parts, the pick proper F and the withdrawal unit P. Consisting of a mild steel barrel, the pick proper incorporates a hardened steel piston; hardened valve G and liner H; valve plates J; steel anvil block and guide K; hardened steel spring block L; steel spring M; and mild steel screwed end cover N.

The withdrawal unit P comprises a cast iron cylinder Q incorporating a cast iron piston R sealed on the underside by means of a cup leather S and provided with four spring-loaded cushion valves T with ball-and-mitre seats. For obtaining a differential effect in the downward working pressure and the upward withdrawal pressure, the rod on the underside is larger than that on the upper side; each rod passes through a gland at its respective end of the cylinder.

The complete pick unit is totally enclosed in a special silencer casing U, packed with insulating material and incorporating a rubber foot V at the lower end to act as a shock absorber when the unit

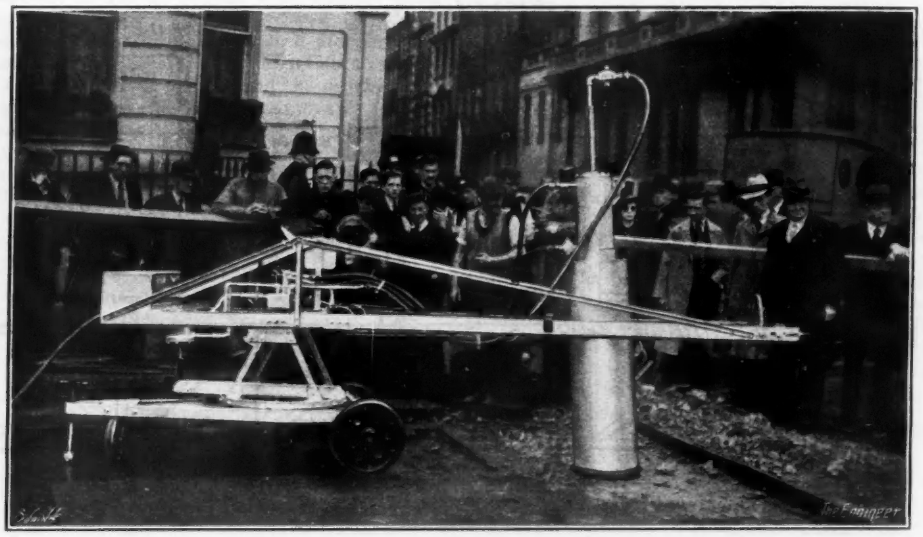


FIG. 2—CONCRETE BREAKER IN ACTION

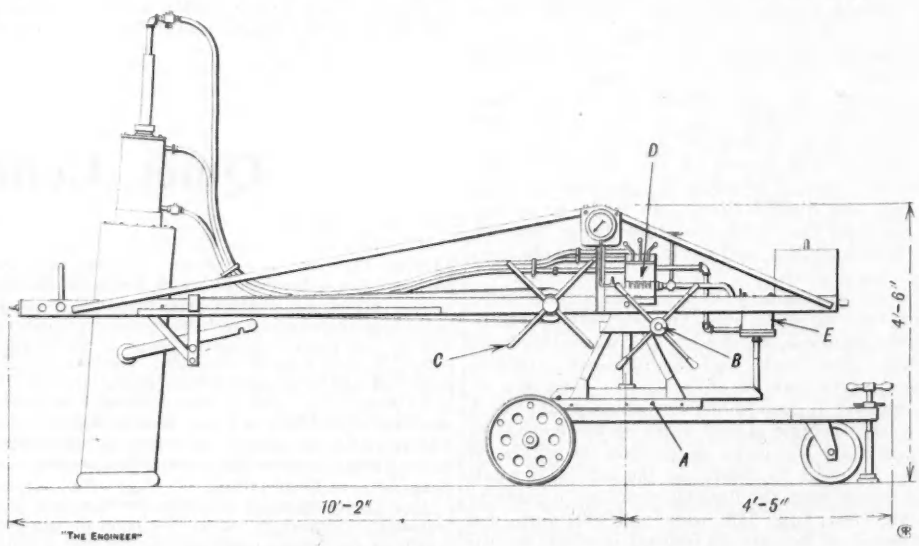


FIG. 3—ARRANGEMENT OF QUIET CONCRETE BREAKER

is lowered on to the ground, and to retain all sound waves within the casing.

At D in Fig. 3 is indicated the control valve unit. It consists of a gun metal block with three control valves, each provided with a hardened and ground steel piston. The valves are operated by means of ball-ended levers working in gates. Air is led in from the main source of supply at the rear end of the machine and carried by means of a wrought iron pipe to the control unit, which is ported, so that by operating the levers air can be admitted to the positioning cylinder E, the withdrawal cylinder P (Fig. 4), or the pick proper F, at will. The hammer of the pick is actuated by means of a piston weighing 9 lb., which reciprocates at a rate of about 1000 beats per minute. The blow of the hammer is taken on a hardened steel anvil block W, which, in turn, transmits it to the shank of the pick X.

As a whole, the pick unit is mounted on three guides equally spaced around a barrel which slides in small grooves arranged in the silencer casing. During the

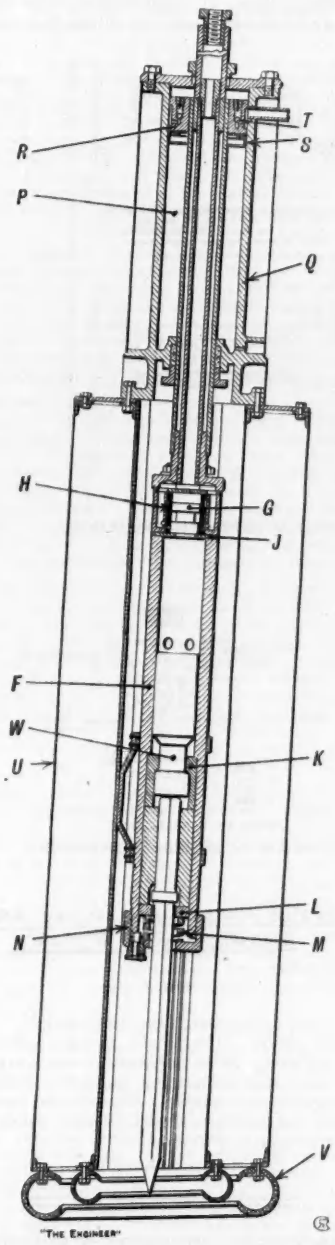


FIG. 4—SECTION THROUGH DRILLING COMPONENT

operation of lowering or raising the pick, the whole pick unit moves up and down within the silencer casing and in this manner the feed through the concrete is obtained. The picks are interchangeable, the change being made easily by removing the end cover to release the pick, spring block, and spring.

METHOD OF OPERATION

With the jib raised so as to lift the pick casing 3in. or 4in. from the ground, the machine is wheeled on to the concrete to be broken. The casing is then run out to the extreme end of the jib, and the jib slewed over to one side by means of the capstan wheel turntable control. By operating the first and second control valve, the casing is lowered on to the concrete. As soon as it touches the concrete the third control valve is operated, putting the drill into action. By watching the piston-rod which extends through the top of the extractor cylinder, it can be readily seen when the pick has broken right through the concrete, whereupon the three controls are pushed back simultaneously to extract the pick and raise the casing.

The jib is then slewed about 12in. to the right or left, as may be required, and the above operations repeated. Without shifting the machine as a whole, the drill and casing can then be pulled back along the jib, giving successive working positions, much after the fashion of a radial drilling machine. After it has been pulled back along the beam to its inmost position, the whole machine is run bodily backwards to a new working position and all the opertaions repeated.

We are informed that the total time taken for one complete operation—that is to say, lowering the casing and breaking through concrete—takes from five to twelve seconds, and that it takes one second to withdraw the pick. This time, of course, varies with the thickness and quality of the concrete, and also with the horizontal width of concrete taken at one "bite." It is found that a width back from the face of the broken concrete of about 5in. is the best distance, and that at this distance the pick does not get jambed. Also it is pointed out that the pick is driven completely through a slab of concrete in one operation, and it is not necessary to break it in steps—the usual method with hand-operated picks.

The manipulation of the pick is simple and merely requires a finger pressure on the controls; also the controls for traversing the casing and slewing the jib are light in action. It is pointed out that this lightness of control relieves the operator of all physical effort, while at the same time a high degree of silence has been obtained.

Locomotive Research and Development*

No. III

(*Continued from page 164, August 11th*)

INDIA: B.B. AND C.I. RAILWAY RESEARCH

Scope of the Investigations.—Research work has been undertaken by the B.B. and C.I. Railway and by the Railway Board, acting independently. The investigations of the former involved:

(*a*) Designing a recording mechanical oscillograph for bogie movement.

(*b*) Making a series of records for engines in different conditions of bogie and hind truck control, and in different conditions of maintenance.

(*c*) Exploring the relation between packing of the track and engine oscillation, making use of whitewash to record track defects.

The work was initiated in 1930 following displacement of the track by "X C" engines during the monsoon. The recording apparatus for bogie movement in relation to the main frame was first adopted in January, 1931, and it has since been used at intervals to investigate riding problems as they arise.

Description of Oscillograph.—The recording instrument is carried on a bracket attached to the bogie centre frame stretcher on the engine; it consists of an arrangement by which a roll of tracing cloth about 5in. wide is driven by suitable gearing from one of the bogie wheels. The tracing cloth passes under three pencils, the outer two of which record time and distance (mile posts), whilst the central one, which is operated from a bracket fixed to the bogie stretcher plate, records displacement.

The drive is effected by means of a belt between a pulley, which is bolted to the outside of one of the bogie wheels, and a countershaft running across the top of the engine framing, from which a second belt leads down to drive the oscillograph. The point from which the displacement is taken is about 1ft. 9in. ahead of the bogie centre, so that the movement recorded is compounded of bogie rotation and displacement of slides. The apparatus is robust, and, by scribing the record of the movement directly on to tracing cloth, copies of the record can be simply taken after inking.

Deductions from Use of Oscillograph.—As displacements only are recorded, and no means of measuring flange forces had been developed, the series of graphs obtained show a continuous reduction in relative movement between bogie and main frame, as more friction is added to bogie and hind truck; the deductions made were the same as those reached by the Railway Board, namely, that the troubles experienced with these "Pacific" engines can best be cured by retaining a light bogie control spring, lining the bogie slides with friction material, fitting a flat Ferodo-faced slide to the hind truck, and adopting German draught gear.

Previous to these final deductions, trials had been made by increasing the bogie control within the limits of the original design, increasing the inclination of the Cartazzi slides, and cutting out sections of the compensating gear; none of these materially effected improvement. In 1934 a complete bogie was obtained having roller bearing axle-boxes and laminated spring side control; the centring force was 3 tons initial and 4½ tons final. Used in conjunction with the Cartazzi slides no improvement resulted.

During our visit, new laminated springs were, at our request, made and fitted to this special bogie having an initial load of 5 tons and a final load of 8 tons. The engine was also fitted with flat Ferodo hind truck slides, and with modified German draught gear, in which flat side buffer faces were provided rubbing on Ferodo. The buffers were fitted with collars to their spindles, so that when the engine traversed a curve, only one buffer at a time came into action. The oscillograph was fitted up on this bogie on "X C," "No. 614," and a very smooth graph was obtained over a portion of the main line between Kotah and Dohad, which had considerable curvature.

Relation between Packing of the Track and Engine Oscillation.—In 1932 some interesting and valuable trials were carried out on a stretch of line ¼ mile long, over which oscillation had been experienced with "X C" class engines. At intervals of approximately 20ft., the following measurements were taken:—

Vertical alignment.
Horizontal alignment.
Gauge.
Unloaded cross levels.
Deflection under engine at 60 m.p.h.
Cross levels under engine load at 60 m.p.h.

Throughout these trials the engine used was one known to hunt at speed on this particular section, and its condition was not varied; but with the object of discovering the effect of track conditions on hunting, the track was repacked after each test. It was also desired to ascertain whether hunting could be damped out if the track were more efficiently packed. The measure of hunting corresponded with the amount of whitewash which was ejected by a special fitting carried on the engine. The chart showed that successive packing of the track gradually reduced the tendency to hunt.

These investigations, which to the best of our knowledge were original, are of value because they show that the B.B. and C.I.R. authorities were thinking on the right lines, so far as the interdependence of track and engines is concerned; it was thus demonstrated that hunting can be practically cured if intensive attention is paid to the track, and this confirms what we have set out in Chapter III on this subject.

The fact, however, that this desirable result for these particular engines requires a standard of track maintenance financially impracticable does not detract from the value of the experiments, which establish an important relationship between track maintenance and engine hunting. One beneficial effect of these trials was that attention was focused on track, and the B.B. and C.I.R. accelerated their programme of renewal of some 200 miles of wooden sleepers with steel troughs on 90 lb. F.F. rails. Since these measures, the "X C" engines on this railway, even in original condition, are reported to have given no further trouble in this respect.

RAILWAY BOARD RESEARCH

Origin.—In continuation of the experimental work in connection with "X" class "Pacifics," which has been described in Chapter II, the field of research was extended in 1935. The matter was approached from two complementary angles, first, to determine the actual flange forces exerted, and secondly, to ascertain the resistance of different tracks to those forces. It is intended in this section to deal with the locomotive first, as it is to this that most attention has so far been given. Track research will be described and discussed in the latter part of this section.

Two officers from the civil engineering staff were placed on special duty, and the following extract from their report describes the apparatus used so far as the locomotive is concerend:—

We were instructed to undertake a research into the permissible axle loads and speeds on various types of railway track existing in India. We commenced our investigations in the winter of 1935 with the following terms of reference:—

(1) To verify or otherwise the speed allowance formula *vide* item D (4) of Technical Paper No. 245 for the increment of rail stress due to the passage of a wheel load on a rail at speed due to the elastic character of the support.

(2) To investigate the increment of stress over and above the static effect that may be expected to arise under normal conditions from defects in the track such as low points, rail joints, or non-

* Being Chapter VII of the Report of a Committee on "Pacific" Locomotives on Indian Railways. India Office. Price 6s. 9d. Some of the diagrams have been omitted owing to the impossibility of reduction.

uniformity in the support offered by adjacent sleepers.

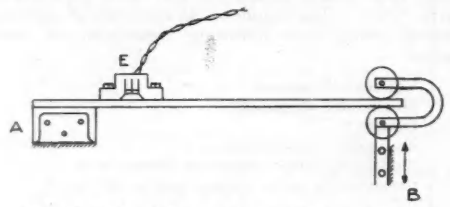
(3) To investigate the conditions of support at rail joints with a view to determining what reliance can be placed on the rail continuity effect of fish-plates, both new and worn, and the effect of closer sleeper spacing.

(4) To investigate the conditions of stability in the ballast of various types and designs of sleepers, including recent designs of the Central Standards Office from the point of view of reducing maintenance and preserving a level track surface.

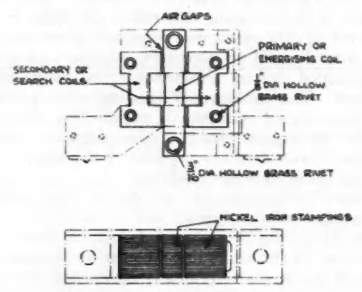
(5) To investigate the effects on rails and sleepers of the lateral forces on rails arising from the hunting movement of locomotives at speed, both on straight track and on curves.

By the summer of 1937 our investigations covering the first four items were completed, and the results indicated that so far as a vertical axle load is concerned, axle loads of 19 tons could be run safely on almost any weight of rail on broad-gauge tracks at speeds of 60 m.p.h. There remained, however, the investigation of the important matter covered by item (5), and it was evident that no reliable conclusions could be drawn unless due account was taken of the lateral forces which tracks are called upon to bear.

The experimental investigation of the effects on rails and sleepers of the lateral forces arising from the hunting movement of locomotives at speed presented a problem of some difficulty and complexity. One of the handicaps with which we were confronted was the absence of



ELECTROMAGNETIC STRAIN DETECTOR ASSEMBLY



APPARATUS FOR MEASURING DISPLACEMENT. RAILWAY BOARD'S RESEARCH.

"THE ENGINEER"

FIG. 5

any standard type of apparatus suitable for our investigations, and it was necessary for us to design and manufacture the special apparatus required. The apparatus, which was completed by the summer of 1937, was so designed that, when fitted between the axle-boxes of locomotive axles, the flange pressures imposed on the rails could be electrically recorded whilst the locomotives were travelling at speed. In addition, arrangements were made to record the lateral movements of the front and rear of engines by means of electric telemeters of the type used in our earlier investigations with the necessary adaptations to suit the purpose in view.

It was decided to start experimental investigations on the East Indian Railway, and the work was about to commence on that system when the Bihta accident occurred. As a result of this, we were directed to concentrate the investigations practically exclusively on the matter of the running of "X B" class engines and their effect on the track. With periods of intermission, fourteen months in all was spent in testing "X B" class engines. During this period some 180 engine runs were made under varying conditions and on different sections of line, and records were electrically taken of the engine movements and flange forces.

Objects of Investigation.—The objects of the investigation were :—(i) To ascertain the characteristics of "X B" engines when hauling passenger trains on the Indian permanent way at express speeds ; (ii) to determine the inter-relation between the engines and the track to ensure safety.

During the investigation tests were carried out on the following railways :—East Indian, North-Western, Madras and Southern Mahratta, South Indian, Great Indian Peninsula.

The scope of the tests covered classes of tracks with rails of medium weight, such as 82 lb. B.H. on the Great Indian Peninsula Railway and 88½ lb. B.H. on the East Indian Railway. Tests on the other railways were carried out on track upon which the engines have hitherto normally operated at unrestricted speed, *i.e.*, 60 m.p.h.

Description of Apparatus Used on Locomotives.—The general character of the apparatus used on the locomotives has already been indicated. In addition, an optical recording seismograph was used for testing lurch movements. This instrument is described in a paper read by one of the writers before the Institution of Civil Engineers and published in the "Proceedings" of that Institution in Vol. 237, pages 354–355, and in the eleventh report of the Indian Bridge Standards Committee. The equipment on the locomotive also included scribers and "scratch plates" for indicating maximum amplitudes of the bogie slide and of the hind truck axle-box movement.

For the purpose of electrical recording, a five-element electro-magnetic strain gauge recorder was employed. Of the five elements, three were adapted to record movements relative to the engine frame, such as those of the bogie slide, bogie pivot, coupled axle-box, hind truck axle-box, and hind truck axle. The remaining two elements were designed to record flange pressures.

Measurement of Relative Movements or Deflections.—The principle adopted is shown diagrammatically in Fig. 5. The bracket A carrying a cantilevered spring steel strip is securely bolted to the first member in such a direction that the relative movement of the second member will be normal to the cantilevered strip. An operating bracket B, incorporating two rollers, is bolted to the second member so that relative movement results in bending strain in the strip closely proportional to the relative movement between the two members. The electro-magnetic strain gauge detector E is attached at a position along the cantilever strip where the range of strain is of a suitable magnitude for recording. The electro-magnetic principle in both movement or deflection and flange pressure detectors is the same, but in the former case they take the form of separate units.

The elements for recording lateral forces consist of weigh bars in the form of tubular struts, illustrated in Fig. 6, fixed in pairs between the axle-boxes, the channel liners of which are planed down at X to give sufficient clearances to ensure proper functioning of the weigh bars, which requires that the path of the lateral forces between the flanges and the locomotive frame shall be *via* the weigh bars or struts. The thickness of metal of the tubular struts is reduced to 0·19in. over the length G G and strain on this length is detected by an electro-magnetic strain detector assembly. In the assembly are three wound laminated cores of Rhometal separated by air gaps of 0·020in. The central core, on which is wound the energising coil, is rigidly connected to one end of the gauge length by means of a duralumin forked plug. The two outer cores, with their windings connected in opposed series to give the difference of the voltages induced in them, are rigidly connected together, and to the other end of the gauge length by means of duralumin frame plates and plug. When a load is applied to the weigh bar, the strain on the gauge length closes the air gap on one side of the central core and opens it on the other, thus increasing and reducing the induced voltages in the respective outer core windings. As arranged for use, the number of turns on each of the outer coils is different so that under no load the difference of the induced voltages is 5 volts decreasing with load. Up to the maximum load the variation of voltage is very closely linear. The weigh bars are made in matched pairs and are retained between the axle boxes by means of hemispherical sockets. The net induced voltages from each of a pair of weigh bars are added so that the total of the two net induced voltages varies linearly with the total load on the pair of weigh bars, and is independent of the actual distribution of the load between weigh bars.

The energising power is obtained from an oscillator amplifier delivering about 6–7 watts at 6000 c.p.s. The whole of the electro-magnetic strain detector assemblies are connected in parallel with each other. This parallel group is connected in series to a condenser to form a series resonant circuit which presents a load of pure resistance to the amplifier. The impedence of each assembly is practically constant for the working variations of the air gaps.

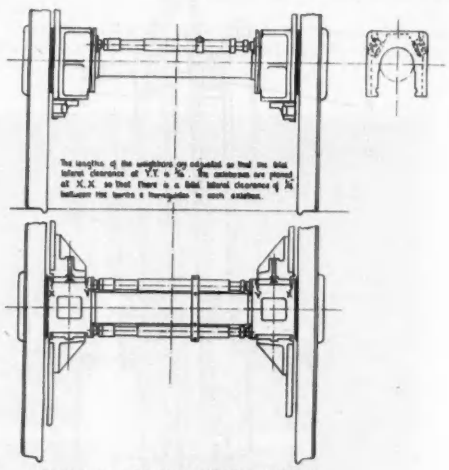
From each pair of weigh bars and each deflection meter the net induced voltage is applied to the grids of a pair of valves arranged for rectification. The anode current from each pair of valves is filtered and passed through an adjustable resistance to a Duddell type oscillograph tube. The filters are designed to cut off at about 60 c.p.s. in the case of the weigh bars and 20 c.p.s. in the case of movement or deflection meters.

The battery of oscillograph tubes with their electro-magnetic D.C. field coils are arranged at one end of a light-tight box which forms the "bellows" of a camera. The film box is set at the other end, but not touching the "bellows" box, the connection being made by means of a labyrinth light trap. Images of a straight filament are thrown on to a cylindrical lens in front of the film by the oscillograph mirrors. The cylindrical lens reduces this line image to a point image on the film. A slit 0·010in. wide is placed across the film to protect it from stray images and dispersion. The film is wound past the slip at any required speed by a small motor. The "bellows" box is mounted on a sponge rubber mat 1in. thick to protect the oscillograph tubes from possible vibration from this motor.

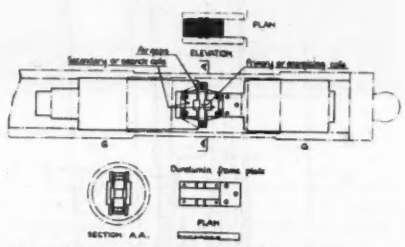
The whole group consisting of oscillator amplifier, rectifying valves and camera oscillograph is mounted on a board and slung from the roof of a bogie vehicle by rubber ropes. In practice the suspension is satisfactory and no influence of train motion can be detected on the records.

Method of Calibration : (*a*) *Deflection Meters.*—A direct calibration is obtained by moving the free end of the spring steel cantilever strips through a measured distance and adjusting the oscillograph by the variable attenuators to give a convenient scale. The scale adopted is 1 cm.=1in.

(*b*) *Weigh Bars.*—A direct calibration is obtained by applying known loads in a calibration assembly



ASSEMBLY OF WEIGHBARS BETWEEN AXLEBOXES



ELECTROMAGNETIC DETECTOR FOR WEIGHBARS

APPARATUS FOR MEASURING FLANGE FORCES. RAILWAY BOARD'S RESEARCH.

"THE ENGINEER"

FIG. 6

and adjusting the weigh bar oscillographs to a convenient scale. The scale usually adopted is 1 cm.=5 tons. The calibration can vary about 5 per cent. due to heating up of the oscillograph tubes by the field current. To minimise errors due to such variations calibrations were taken before and after each day's tests.

(*To be continued*)

MARINE WIRELESS EQUIPMENT.—A radio telephone-telegraph equipment has been specially designed by the British Power Boat Company, Ltd., of Hythe, Southampton, for use on high-speed craft where low weight, economy of space, simplicity of operation, reliability and efficient performance are of primary importance. The equipment is designed for telephony, C.W. and I.C.W. transmission on 100–200 m., and C.W. and I.C.W. on a 500–600 m. wave band. To promote a simple lay-out, rapid installation and ease of operation, the number of units has been reduced to a minimum. Housed in a water-tight box composed of a salt-resisting light alloy, the equipment can be used under tropical conditions. All the controls are simple. Doors at the front of the units enable the equipment to be swung out without removing them from the fitted position, and the high-tension supply to the transmitting unit is automatically cut off when the door is opened. Constructed for a 12 or 24-volt supply, the equipment can, if desired, be operated by the ship's batteries. High-tension for the receiver is obtained from a vibrator unit which is silent in action. By means of tuning, the drive circuit and aerial taps, the four predetermined spot frequencies can be modified to give any desired wavelength between 100 m. and 200 m. The receiver covers a wave band of 100–200 m., 500–1000 m., and 1000–2000 m. Although the working range is dependent on the type of aerial fitted to the boat, with a normal outside aerial distances up to 100 miles for telephony and 200 miles for I.C.W. have been obtained under normal sea-going conditions.

Rail and Road

ROAD VEHICLES: NEW REGISTRATIONS.—A return issued by the Ministry of Transport shows that the number of new motor vehicles registered in Great Britain during the month of June, 1939, was 40,844, compared with 34,740 in June, 1938.

TRAIN ACCIDENT IN SWITZERLAND.—A local passenger and goods train was derailed when travelling at high speed near Domo d'Ossola, on the Swiss-Italian frontier, on the night of Friday, August 11th. Six people were killed and the line to the Simplon Tunnel was blocked by the wreckage.

KASHIPUR–KALAGARH RAILWAY.—It is reported that the Indian Railway Board has under consideration a project for constructing a branch line between Kashipur and Kalagarh, United Provinces, a distance of 31·41 miles, at an estimated cost of nearly Rs. 19,00,000, excluding rolling stock.

RAILWAY ACCIDENT IN THE UNITED STATES.—On the night of Saturday, August 12th, the trans-Continental express, "City of San Francisco," of the Southern Pacific Railway, plunged over a bridge into a river 17 miles from Carlin, Nevada. Nineteen people were killed and sixty-one injured. It is reported that the accident has been attributed to sabotage effected by displacing one of the rails.

WORLD MOTOR VEHICLE STATISTICS.—A report of the United States Department of Commerce states that at January 1st last there were nearly 43,820,000 motor vehicles registered in the world, an increase of 1·7 per cent. on the number last year. Of these vehicles nearly 30 million were registered in the United States, 2,611,000 in Great Britain, 2,251,300 in France, 1,816,200 in Germany, and 1,375,130 in Canada.

SOUTH AFRICAN RAILWAYS.—The annual report of the South African Railways and Harbour Board shows that rolling stock valued at over £4,852,600 was placed in service during 1938, and stock authorised, under construction, or on order, was valued at over £7,439,000 at the end of the year. Passenger traffic increased to nearly 112 million journeys during the year, but goods traffic declined by 869,400 tons to 19,076,540 tons.

NIAGARA FALLS BRIDGE.—Construction of a new bridge at Niagara Falls was authorised last year by the United States Congress. Preliminary borings were made, but, as the War Department contended that they did not constitute an actual start of the work, it became necessary for the Bridge Commission to obtain an extension of time from Congress. Time for starting the work was extended to June 16th, 1940, by a new Bill. The new Bill, however, repeals a provision in the original one which exempted bonds of the Commission from taxation.

BRIDGE WIDENING AT LIVERPOOL STREET.—In connection with the London and North-Eastern Railway Company's electrification scheme to Shenfield, the construction of a new widened bridge at Worship Street, just outside Liverpool Street Station, is taking place simultaneously with the demolition of the old bridge. The new structure will require over 400 tons of steel work and about 600 tons of material comprising the old bridge is being removed. Work is proceeding without interruption to the operation of the 1264 trains passing daily on the lines below.

STOBCROSS WEST JUNCTION ACCIDENT REPORT.—The report has been issued on the accident which occurred on February 22nd last at Stobcross West Junction, when the 1.52 p.m. up passenger train from Possil to Rutherglen ran into the side of the leading coach of the 1.2 up passenger train from Balloch to Rutherglen. One passenger was killed and a number injured. The primary responsibility of the accident was placed upon the signalman in Stobcross signal-box, who accepted both trains, and a lesser degree of responsibility was borne by the driver of the train from Balloch, who failed to see a ground signal at danger, but stopped at another signal a little further on.

RAILWAYS IN SIAM.—Dealing with railways in a recent report on the conditions in Siam—or Thailand, as it is to be known in the future—Mr. W. W. Coultas says that there has been no important extension in mileage during the past two years. Progress on the Khon–Udorn line, for which nearly 3 million ticals has been budgeted, has been delayed through exhaustion of the stock of rails. During this year all the remaining earthwork is to be completed and plate laying is to be continued, as well as the construction of five stations and the purchase of steel bridges. The remodelling of Bangkok station yard at a cost of over 787,000 ticals is to be completed during 1940. The existing Makasan workshops are being enlarged and modernised at a cost of about 5 million ticals, and will take five to six years to complete.

CENTENARY OF A MIDLANDS LINE.—One of the earliest rate wars between British railways is recalled by the centenary of the public opening of the Birmingham and Derby Junction Railway, whereby rail services were made possible between London and Tamworth, Burton-on-Trent, Nottingham, and Derby. For nearly a year the Birmingham and Derby Junction Railway, in conjunction with the London and Birmingham Railway, which it joined at Hampton-in-Arden (Warwickshire), afforded the only rail route between London and several important centres in the Midlands, but the opening of the rival Midland Counties Railway from Derby and Leicester to Rugby on July 1st, 1840, led to feverish competition for the through London traffic, in the course of which the first class fare for through London passengers over the 38¼ miles from Derby to Hampton-in-Arden was cut from 8s. to 2s. and the second class fare from 6s. to 1s. The war ended in 1844 with the amalgamation of the rival lines, together with the North Midland Railway, to form the Midland Railway; all these lines are now part of the London Midland and Scottish Railway Company's system. The major portion of the original Birmingham and Derby Junction Railway now forms part of the L.M.S. main line between Birmingham and Derby, but the section from Whitacre to Hampton-in-Arden is now closed entirely for through traffic after having carried very little traffic for many years.

Miscellanea

DISCOVERY OF MOLYBDENUM ORE IN FRANCE.—It is reported that French workmen, carrying out repairs to a road in the Vosges, have discovered rich deposits of molybdenum ore.

TRAINING IN REFRACTORY MATERIALS.—In order to meet the growing demand for men with special training in refractory materials, the University of Leeds has arranged a one-year course leading to a post-graduate diploma in fuel and refractory materials. The new course, which begins in October next, will be given in the Department of Coal Gas and Fuel Industries, and will be additional to the normal instruction received by students reading for degrees in gas engineering and in fuel and metallurgy.

A LARGE BESSEMER SHOP.—The construction of what is said to be the largest Bessemer department in Europe, with a daily output of 5000 tons of steel, has been completed at the Krivoi Rog Iron and Steel Works, Ukraine. The new plant, which is shortly to be put into operation, is fully mechanised and embodies all the latest developments in steel production. The new department is a valuable addition to the Krivoi Rog Works, which already has two blast-furnaces of 930 cubic metres in volume and one with a volume of 1300 cubic metres.

AN UNUSUAL METHOD OF PROSPECTING.—Two Swedish scientists have developed an unusual method of prospecting which has been the subject of a series of successful experiments. The principle of the method is that if minerals are present in an area they will leave traces in the water solutions in the earth, in which they are absorbed in varying degrees, according to their density and solubility. Trees and shrubs suck up the mineral-bearing water solutions, and the metals are stored in their leaves. By examining these leaves by laboratory methods, the presence of minerals in an area can be ascertained.

GENERATION OF ELECTRICITY.—The official returns rendered to the Electricity Commissioners show that 1918 million units of electricity were generated by authorised undertakers in Great Britain during the month of July, 1939, as compared with the revised figure of 1656 million units in the corresponding month of 1938, representing an increase of 262 million units, or 15·8 per cent. The number of working days in the month, *i.e.*, excluding Sundays, was twenty-six, the same as last year. During the seven months of 1939 up to the end of July, the total amount of electricity generated by authorised undertakers was 15,488 million units, as compared with the revised figure of 13,609 million units for the corresponding period of 1938, representing an increase of 1879 million units, or 13·8 per cent.

FASTENING STUDS IN SOFT METALS.—A new system of fastening high-tensile studs in soft metal alloys has been developed in the United States. It is known as the "Aero-Thread" screw system and has been particularly designed for aircraft work, such as where cylinder holding studs are fastened into aluminium or magnesium alloy crankcases. As described in the *Iron Age*, the outstanding feature of the system is the use of a spirally wound insert or bushing of high-tensile bronze spring wire. This insert fits into the tapped hole by screwing into the threads by means of a special inserting tool and a tang on the entering coil. Once the insert is installed it becomes a fixed part of the tapped hole. When the stud or cap screw is assembled its bearing is against the spiral bronze insert, instead of the softer metal of the light alloy part.

CAUSES OF THE NORWICH ELECTRICITY FAILURE.—An official statement issued by the Electricity Committee deals with the causes of the failure of the Norwich and district electricity supply on July 28th. It is explained that the main switchgear has been undergoing extensive modification for some weeks past, and that this process was still going on at the time of the failure. During a series of switching operations made necessary by the alterations, an error was made, and a panel which had previously been made "dead" was connected with the main switchgear 6600-volt bus-bars, which were being supplied at the time by generators at the Thorpe station, and to which also the grid was connected. The result was a fire, which, although extinguished in about a minute, caused damage estimated at £2000.

SPARKING PLUG ELECTRODES.—Results of a number of tests carried out on a knock testing engine, to determine the effect of sparking plug design and material on knocking, are given in an abstract from *Brennstoff Chimie* in a recent issue of the *Automobile Engineer*. Plugs tested had three electrodes machined from the body proper, thereby eliminating welded or riveted joints, to take full advantage of the high heat conductivity of the metals used. With copper as a body and electrode material, the octane number of the fuel in use was improved from 54·7, observed with a standard plug, to 58·5. This plug gave satisfactory service during the two hours of test. Similar results were obtained with a mica plug equipped with copper electrodes, the octane number improvement amounting to 2·6 units. With brass as electrode material, the effect was less, while aluminium and lead had no effect at all.

PITHEAD BATHS.—The seventeenth annual report of the Miners' Welfare Committee, in dealing with pithead baths, says that the work executed and paid for during the year amounted to £825,338. Pithead baths for 400,016 persons at 313 collieries had been provided by the Central Committee by the end of 1938, including 58 installations under construction. New installations were completed during 1938 at 47 collieries and six existing installations were extended. These have provided for 55,558 men and 54 women, a record output of completed work for a single year. The total outlay involved is £5,452,896, of which the contracts in progress amount to £1,143,000. Of this total the Baths Fund has provided £5,054,623, and the District Fund £398,273. Preparations are in progress for 73 new installations, which will cost about £1,300,000. The Central Committee has work in hand to a total value of nearly 2¼ million pounds, and the other applications yet to be dealt with number 169, at a probable cost of about £2,250,000.

Air and Water

PROPOSED NEW FRENCH LINER.—It is reported that the Compagnie Générale Transatlantique will place an order for a new liner of about 85,000 tons within the course of the next few months.

SHIPBUILDING YARDS IN NORWAY.—According to reports, a scheme has been prepared in Norway for the laying-down of a new shipyard at Sjursöcja, near Oslo, for the construction of standard cargo ships of 15,000 tons.

NEW AIR LINERS FOR SOUTH AFRICA.—There will shortly be delivered to South Africa two new Junkers "J U 90" air liners, fitted for the accommodation of twenty-eight passengers. The machines have a cruising speed of 215 miles an hour, with a pay load of 13,200 lb.

NEW TURKISH MERCHANT SHIPS.—The Turkish Ministry of Communications has invited tenders from this country for the construction of eleven merchant ships. Four of the ships will be of 4800 tons, and seven of 1800 tons, and it is estimated that the vessels will cost about £2,000,000.

THE "SQUALUS" MOVED.—The United States submarine "Squalus," which sunk with the loss of twenty-six lives near Portsmouth, New Hampshire, in May last, has been raised about 70ft., and towed into shallower water. The vessel originally sank in 40 fathoms, and is now resting on a mudbank in about 28 fathoms of water.

NEW SHIPYARDS IN NORTH RUSSIA.—The largest shipbuilding and ship-repairing works in the north of the Soviet Union is being built at Limenda, on Mikheikov Island, at the confluence of the rivers Vychegda and Northern Dvina. The estimated cost of these works, which will be completed by 1942, is more than 32 million roubles.

ADMIRALTY CONTRACTS ON THE CLYDE.—With the placing of contracts for the construction of thirteen vessels recently the Admiralty now has seventy ships on order from the Clyde. They represent over 260,000 tons displacement and are being built by fourteen different firms. The latest ships ordered include six trawlers, four boom defence vessels, a dredger, and two special type patrol vessels.

LLOYD'S REGISTER SCHOLARSHIP IN MARINE ENGINEERING.—The Lloyd's Register Scholarship in Marine Engineering, of value £100 annually and tenable for three years at a British university, awarded by Lloyd's Register of Shipping on the results of the 1939 studentship examination of the Institute of Marine Engineers, has been won by James Sloan, apprentice to Harland and Wolff, Ltd., Belfast, and student of Belfast College of Technology.

PROPOSED REFUGE HARBOURS ON GREAT LAKES.—A report on the Great Lakes by the United States Divisional Engineer, to determine the cost and advisability of providing refuge harbours for light draught vessels, recommends the surveying of thirty-one localities for such harbours. It is suggested that surveys be made at twelve places on Lake Superior, seven on Lake Michigan, seven on Lake Huron, three on Lake Erie, and two on Lake Ontario.

SUBSIDY FOR AUSTRALIAN SHIPPING.—A decision has been reached by the Government of Australia to grant a subsidy of £150,000, spread over the next three years, on ships between 100 and 1500 tons built in Australia. The subsidy will be applied in the form of a bounty of £12 10s. per ton on vessels between 100 and 750 tons, and then at the rate of £10 per ton on vessels up to 1500 tons. British vessels between 100 and 1500 tons will be admitted duty free. Machinery, boilers, and auxiliary supplies from Britain will be admitted duty free.

NEW CLYDE FERRY.—Negotiations are in progress between the London Midland and Scottish Railway Company and the local authorities for the setting up of a vehicular and passenger ferry service between Gourock and Dunoon. When the negotiations have been completed it is expected that about £15,000 will be spent on reconstructing the piers to meet the needs of the new service. The ferry vessel contemplated for the service will be capable of carrying about 450 passengers and 27 vehicles and its cost is estimated at £50,000.

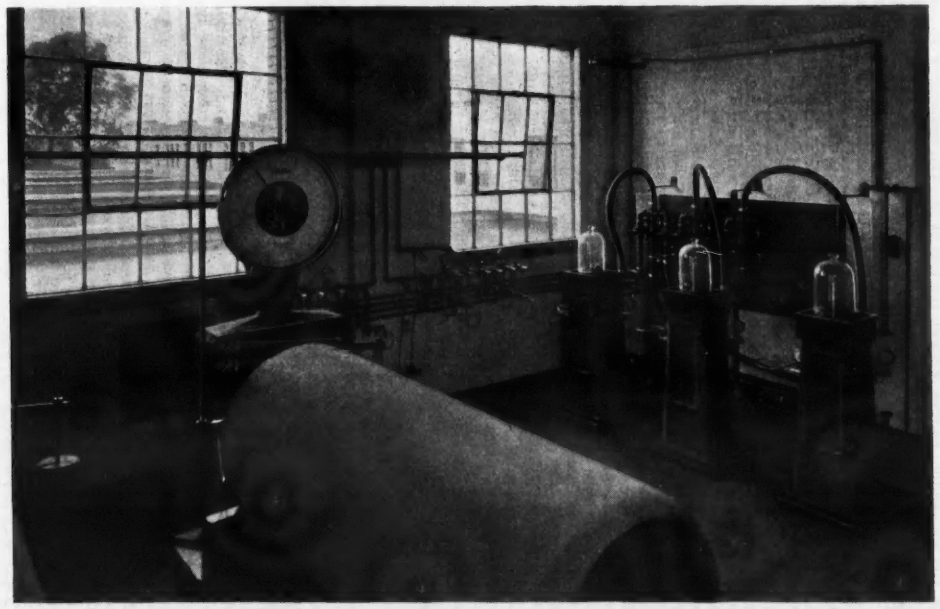
H.M.S. "BELFAST."—The new 10,000-ton cruiser H.M.S. "Belfast," which was launched on March 17th, 1938, has completed successful acceptance trials and is being commissioned at Portsmouth. Built by Harland and Wolff, Ltd., this warship is of the improved "Southampton" class, and has a length of 579ft., with a breadth of 63ft. 4in. Her geared turbines develop a total of 80,000 S.H.P., and drive four propellers. Her main armament comprises twelve 6in. guns, twelve high-angle and four three-pounder guns, and six torpedo tubes.

AN EXPERIMENTAL AIR STATION.—A note in *Flight* says that the United States Civil Aeronautics Authority has recently "taken delivery" of its new experimental station and airport at Indianapolis. The site is just west of the municipal airport, and the field has two 4000ft. runways. At present the equipment consists of a completely developed instrument-landing system, an ultra-high-frequency radio beacon, and a special system of bad-weather runway lighting. Two machines are at present assigned to the station, one a tricycle "Waco" for ultra-high-frequency radio work, and the other a more conventional Stinson "Reliant," for radio approach experiments. The particular approach system in this case is a refinement of the basic system developed by the U.S. Bureau of Standards many years ago.

THE GERMAN MERCHANT NAVY.—A note in *Shipbuilding and Shipping Record*, based on a German source, says that only 19·9 per cent. of the German mercantile marine is now under five years old, and thus in the internationally recognised first-class category. The corresponding figures given for other countries are:—Great Britain, 21·1; Holland, 22·5; Norway, 24·6; Australia and New Zealand, 25·7; Japan, 27·5 per cent. It has been stated by Dr. W. Hoffmann, president of the Hamburg-Amerika Line, that between 1931 and 1938 the total of new construction for German shipping was 1,000,000 tons less than their requirements. During the past three years German shipyards concentrated on foreign orders to the disadvantage of German shipping companies. These companies now had so much ground to recover that they must insist on shipyards giving them a fixed quota.

THE HAMMOND WATERWORKS, HAMMOND, INDIANA, U.S.A.

(For description see page 194)



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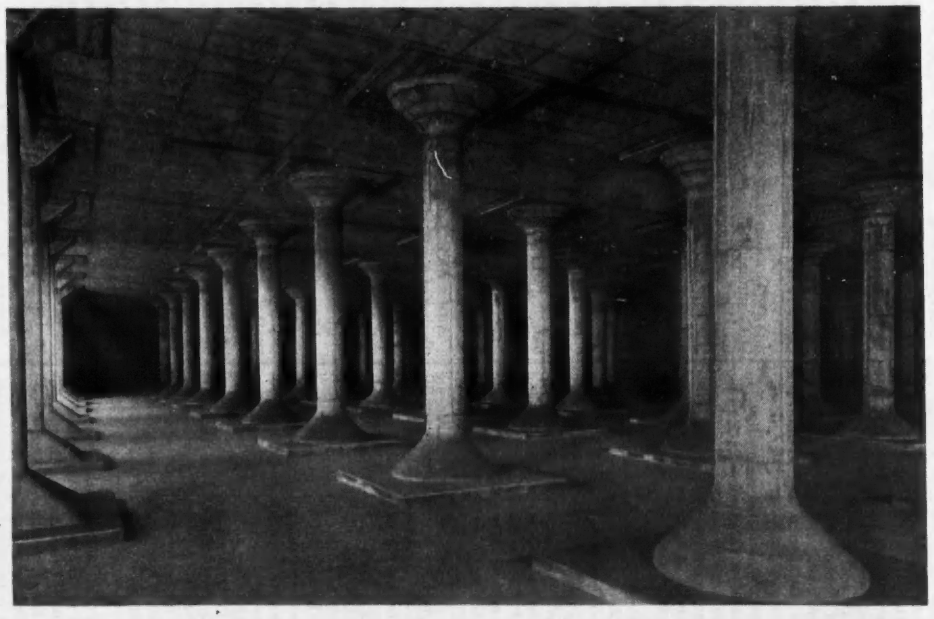
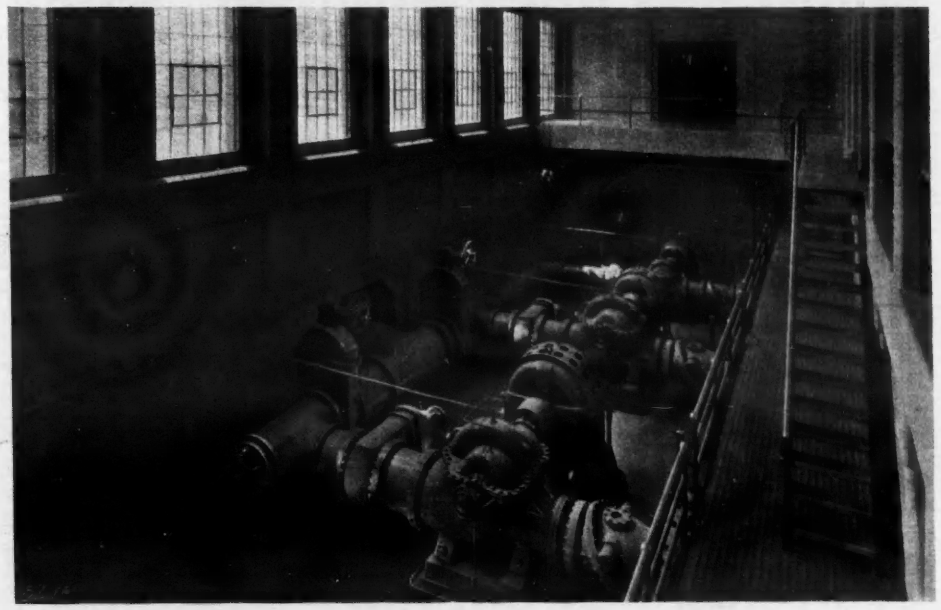
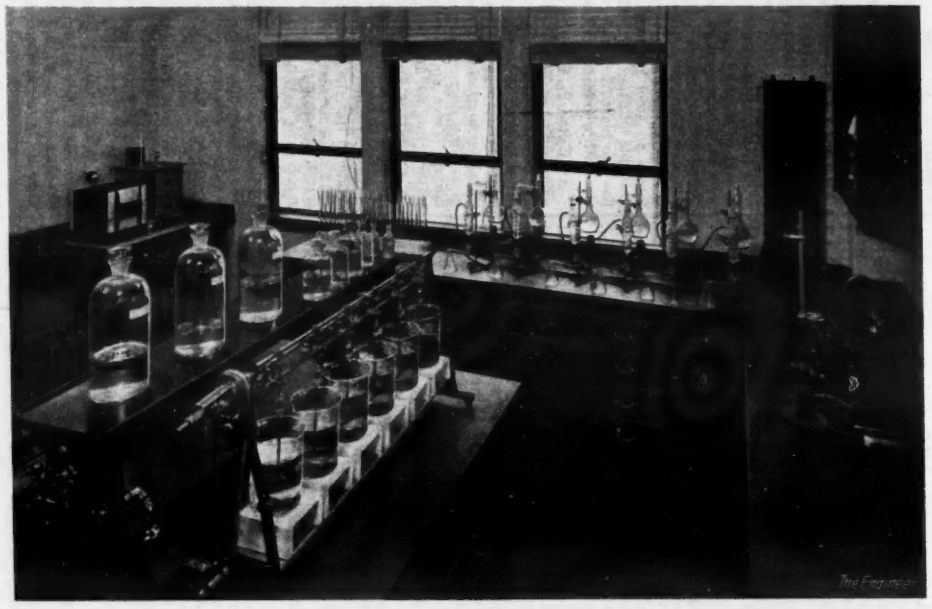


FILTERED WATER STORAGE RESERVOIR
CHEMICAL LABORATORY





The Engineer

AUGUST 18, 1939

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Telegraphic Address: "Engineer Newspaper, Estrand, London." Telephone: CENtral 6565 (10 lines).

THE POSITION OF THE MERCHANT

IN July, 1938, the London Chamber of Commerce appointed a Special Committee of twenty-four merchants engaged in a variety of trades to investigate and report as to whether and to what extent movements exist in various trades tending to eliminate the merchant or seriously to affect his interests in relation to the home and export trade. The Report of this Committee has now been published in a small pamphlet of sixteen pages. It is a pity that no indication is given of the personnel of the Committee or of the trades represented upon it. The complaint which led to the setting up of the Committee originated apparently from the action of a branch of the steel industry in selling certain classes of steel at a cheaper price to consumers than to stockholding merchants. Other complaints were that adequate recognition was not accorded to merchants in the Bill for reorganising and developing the Lancashire cotton trade; that no invitations were extended to merchants by the Government to meet the New Zealand Minister of Finance and Marketing, whilst representatives of a manufacturers' organisation were invited; and that merchants were not asked to attend on an equal footing with the manufacturers in the discussions with the Swedish Trade Delegation. The Committee in its Report states that the subject under review falls under two heads: (1) the action of the manufacturers in so far as it tends to eliminate the merchant; and (2) the attitude of the Government or of bodies enjoying Government protection. The Committee makes it clear that it is only concerned with the genuine merchant, whose contention is that he is able to market the manufacturers' goods more cheaply and efficiently than the manufacturer himself. The Report describes the functions of the stockholding and distributive and export merchant. The classification of the two latter under one heading may evoke some surprise; but probably the reason is that in both cases the goods are ordered by the merchant for direct dispatch to the customer since in few other particulars are their functions similar. After pointing out that there is a wide variation in distribution costs between one order and another, complaint is made of the practice of some manufacturers of laying down an arbitrary figure of so much per cent. allowance to the merchant for distribution services and of selecting "sweet" orders for direct transaction with the consumer, leaving only the "bits and pieces" for the merchant. With regard to the attitude of the Government, the Report expresses the view that in considering any proposal affecting the home, import, or export trades, weight should be given to the effect of the proposal upon the merchants.

The Report is disappointing, in that it puts forward no new argument to support the merchants' case and because it fails to visualise the revolution that has taken place in economic thought and business administration during the past twenty-five years. The conditions in which a merchant plies his calling differ so widely in the various trades that the Report reflects the difficulty of reaching clear-cut conclusions which would have general application. Apparently the Committee found some difficulty in following its terms of reference, since it does not attempt to set out the "extent of movements in various trades to eliminate the merchant"; but, on the other hand, it does ask for greater consideration from the Government where merchant interests are concerned. In practice merchants have little cause of complaint on this score, since Government Departments are always ready to consider any matters brought before them by a properly organised and representative body, whether of merchants or manufacturers. An insistence on a right to meet foreign trade delegations, however, is going rather far. The members of these missions usually have a clear idea of the class of traders they wish to do business with, and it is as well to face the fact that it is seldom that merchants come within this category. It is strange that the Committee has not referred to the changing conditions of trade which have followed the cartelisation of industry, the fixation of prices for long or short periods, and the Association movement amongst merchants in various trades. These developments are anathema to the old-time merchant; but as a class the merchant owes his survival to his ability to adapt himself to changing conditions and still to provide useful service to the community. In view of the economic strains and stresses of the last twenty years, it cannot be doubted that the manufacturers were wise to adopt the Cartel principle, and although this may have been carried too far, the logical result was the establishment of merchant organisations in particular trades. Those merchants who have followed this policy and are prepared to work with the manufacturers in a regulated commercial world have little to fear from the future.

Modern economic thought does not exclude the merchant, but it believes that he must submit to regulations just as much as the manufacturers, and that this can best be done by the formation of representative merchant organisations in particular trades which are able to deal with corresponding organisations of manufacturers interested in the same products. The principle of collective agreement between merchants and manufacturers has superseded the loose, often one-sided, and frequently broken arrangements that previously existed. With the old order passed the merchant slogan, "buy in the cheapest market and sell in the dearest." The merchant of to-day has a wider responsibility to his country, the industry he serves, and the customers who buy from him. The specialisation of merchant firms in particular trades (at least in the British home market) makes it practically impossible for one organisation adequately to represent the interests and aspirations of the merchants of all trades and to this may be attributed the somewhat colourless character of the Report. This is illustrated by the reference to an injustice borne by iron and steel stockholding merchants; but the interests of that section of the merchants are very efficiently cared for by the National Association of Iron and Steel Stockholders, one of the most complete and strongest organisations of its kind.

The French Industrial Experience

A LITTLE more than three years ago industry in France crumbled under a revolution the like of which it had never experienced. To-day, it has come out of the ordeal better organised, more firmly established, and more capable of meeting emergencies than at any time since the great industrial expansion began after the war. The revolution is now a page of history which is already fading from memory, and yet its lessons are so far-reaching that they cannot be allowed to fall into oblivion. They are a record of failures of theories imposed by a Government representing the French section of the International Workers' Union, supported by Communists and the Socialist Right Wing. Following upon a long period of economic stalemate that had demoralised the country, Monsieur Léon Blum made a clean sweep of capitalist influence and of authority in works and factories and allowed workers to become their own masters in circumstances that encouraged them to attempt the concentration of industrial activity in the State. It was the pure Marxist doctrine. We have recorded all the phases of the 2½ years struggle during which employers organised themselves, until they were eventually able to hold their own against the General Labour Confederation that had become an active controlling factor in the State, as well as in national economical and financial administrations. The Marxist organisation collapsed in the second half of last year; the Socialists separated from the Communists, and the minority group of Right Wing Socialists took charge of a hopelessly disintegrated situation. With Monsieur Daladier and Monsieur Paul Reynaud at its head, the new Government has undertaken a complete counter-revolution by means of decrees, and these decrees, covering every phase of national economy, continue to be issued after full consideration has been given to them by the State councils and private associations and groups interested. In consequence of these reforms, confidence has been restored, money is available for public and private enterprise, and the situation has practically returned to normal. These drastic powers would probably not have been so readily conferred on the new Government by Parliament if it were not for the necessity of immediate action in view of international complications.

The question arises—what are the lessons to be learned from this failure of the labour revolt? One of them is that unions affiliated to the Second International can only hope to carry out their plans of world labour control by changing the whole economic structure. Whilst the labourer is worthy of his hire there are economic limits to its amount. The unions endeavoured to extend those limits by suppressing the authority of employers, or at least bringing them under the immediate control of a Socialist State. The extraordinary situation arising out of the revolt of June, 1936, placed employers so completely at the mercy of workers, under the protection of the Popular Front Government, that all industrial activity ceased. Employers were insufficiently organised and had no power to resist. They were deprived of authority, and Communism freely entrenched itself in works and factories. The reign of the General Labour Confederation lasted until employers were able to organise themselves into an equally powerful body with, behind it, the whole country which had become seriously alarmed at the disastrous results of extremist action. It was only when the present Govern-

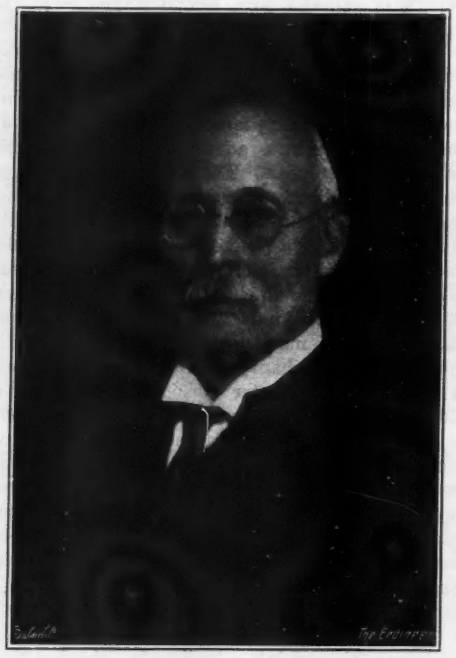
ment took over power and arrested the downfall by abrogating extremist measures, restoring authority to employers, and introducing order and discipline that the Socialist experiment came to an end and left the country determined that it should never be repeated. The forty hours week was the first Socialist law to be ingeniously evaded through a technical loophole. Though still on the Statute Book it is practically a dead letter. A five days week with a Minister of Leisure to provide men with opportunities of making agreeable use of their spare time was a startling innovation that gave an appealing colour to the revolutionary plans. The Ministry of Leisure proved to be a sinecure and had a short existence, but the term "black labour" was coined for men who utilised the two free days to work for pay in competition with artisans. The idea that the forty hours week was a certain remedy for unemployment has died hard. Yet careful inquiries have shown that more than one-half of the men without employment are physically unfit for efficient work because of age or for other reasons, and that among the remainder there are no skilled hands—at least, in the metal and engineering trades. One effect of the forty hours week was the drafting of 60,000 men from other occupations to the railways, which, now that the hours have been increased and economies introduced, find themselves embarrassed with a surplus of hands for whom employment must be found elsewhere. It is the same with all the big public transport companies. Now that men work the number of hours necessary for armament and civil production and receive more pay, they are satisfied with their lot. The failure of the forty hours week is the more complete because it was applied generally, without reference to its practicability or otherwise to particular industries, and it is now recognised that there can be no return to a system that has been tried and found wanting.

In his declaration of policy three years ago, Monsieur Léon Blum made two prophecies that were belied by subsequent events. He averred that a reduction in working hours would not lessen a man's individual output. Statistics, however, showed a decline in hourly production. He also declared as an incontrovertible axiom that higher wages must increase the purchasing power of the working community and bring prosperity to industry generally. Wages, production, and standard of living are so intimately associated that they cannot be dealt with independently. They constitute one economic unit. The reduction of hours with the same weekly pay raised hourly wages by 20 per cent. The cost of production increased, and so did the prices of commodities, despite official price control, and the steady and persistent rise in living costs gave workers the right to claim further wage advances, for the principle of wage adjustments was that they should be governed by the official index of living costs. But in the engineering and other industries wages could not economically follow the rise in living costs. The price of commodities could not be effectively controlled, and it became abundantly clear that high wages could not of themselves bring prosperity to industry, which depends upon increasing production and consumption under the influence of a general atmosphere of confidence. Recognising that fact the new economic policy aims at giving every assistance to manufacturers to increase production by means that will lower costs, and it also hopes to provide facilities for expanding consumption at home and abroad. At the same time, living costs are to be stabilised and, if possible, reduced. Real wages determine the standard of living, whilst indiscriminate advances disturb the general economy. The French Government is giving serious attention to this problem. The failure of the Popular Front experience has swept away fallacies, and allowed of a new industrial order being introduced. Employers' interests are welded in a powerful Federation, new professional and economic associations have been created, and the State economic councils and commissions have a wider influence on Government decisions. They are working together on plans for giving a permanent stability to industry in circumstances of world affairs that are themselves unstable.

Obituary.

LLEWELYN BIRCHALL ATKINSON

The death of Mr. Llewelyn B. Atkinson on Wednesday, August 9th, removes from the electrical profession an exceptionally able man, whose work was widely appreciated. Few engineers have acquired greater popularity or have done more to foster progress. An admirable speaker, lecturer, and a prolific contributor to the Proceedings of the I.E.E. and other institutions, he became a well-known figure in the electrical world, and his death comes as a blow to many engineering and scientific people in this country and abroad. A more versatile man we have never known. Although for many years he was mainly identified with cables, his knowledge of electrical engineering in general was considerable. There were few subjects relating to the industry he could not discuss. Even television claimed his attention in the early days when methods of making it practicable were being sought. His innumerable contributions to discussions, speeches, and lectures would fill volumes. As recently as last June he delivered at the Institution of Electrical Engineers' Overseas



L. B. Atkinson

Members' Conversazione an excellent lecture on "Institution Recollections," when he appeared to be in the best of health and spirits. The services he rendered to that Institution, of which he became President in 1920, were of immense value. He had the happy knack of putting life into meetings and of showing others how papers should be discussed.

Born on August 27th, 1863, the son of a civil engineer, Mr. Atkinson was first educated at the Merchant Taylors' School, London, where his early scientific knowledge was gained in classes and laboratories, set apart for the study of chemistry, physics, and geology. He also attended the evening classes, then just beginning, under Professor Ayrton at the Finsbury Schools, which subsequently became the Finsbury Technical College, where in 1881 he obtained the Silver Medal with Honours at the first examination held by the City and Guilds on electric lighting and power transmission.

After leaving the Merchant Taylors' School, he entered the Department of Applied Sciences at King's College, where in the first year he was awarded the Sambroke Exhibition Medal and in the second and third years the Jelf Medal, awarded to the student who most distinguished himself. On leaving King's College, of which he was elected an Associate, Mr. Atkinson entered the works of Kitson and Co., of Leeds, where he gained a good knowledge of the working of a large engineering factory. In 1884 he entered the Halifax works of Goolden and Trotter and Co., as a pupil, and was subsequently engaged by the firm as an engineer. Later, he became a partner. In 1894, the firm having outgrown the capacity of its works, was amalgamated with Easton and Anderson, of London and Erith, under the title of Easton, Anderson and Goolden, Ltd., and Mr. Atkinson was elected a director of the new company. He also carried on a consulting practice, and was connected with several companies, manufacturing engineering and electrical specialities. In conjunction with his brother, Mr. C. W. Atkinson, he took a prominent part in the introduction of electric power to mining, particularly coal mining, and was the inventor and patentee of various mining electrical appliances. With his brother he owned at Cardiff testing works equipped with electrical, mechanical, and chemical laboratories.

In 1883 he entered as a student the Institution of Civil Engineers and was awarded a Miller Prize for a paper on electrical measuring instruments, in which was published for the first time a method of measuring the power in an A.C. circuit by means of two quadrant electrometers with the needles mechanically connected. In 1900 he was joint author with his brother of a paper read before the Institution of Civil Engineers on electric mining machinery, for which two Telford Medals and Premiums were awarded to the authors. This paper was republished in America, France, and Belgium. With his brother he was also joint author of a paper read before the Mining Institute of Scotland on applications of electricity in mining; also of a paper on a similar subject read before the Staffordshire Institute of Mining Engineers and the South Wales Institute of Engineers, of which he was a member.

In 1886 he took out his first patent for a dynamo brush composed of metal strips interleaved with resistance members for the purpose of preventing sparking, a design which was revived many years later by Mr. W. M. Mordey in a paper he read before the I.E.E. One of Mr. Atkinson's first jobs at the Halifax works was to design in conjunction with Mr. W. H. Ravenshaw a 6 H.P. motor to be built into a bar type coal cutting machine. This is said to have been the first electric coal cutter, and the capabilities of the electric drive were demonstrated as soon as it was set to work. The development of this machine led to his spending a good deal of his time at the coal face.

One of his early experiments, made about 1888, was that of trying to run a laminated field motor with A.C. A motor developed by him as the result of this experiment had in its simplest form two pairs of short-circuited brushes on the commutator with their axes at right angles to one another and the field system connected to the supply. The machine was described in a paper, for which Mr. Atkinson was awarded a Telford Premium, on "The Theory and Working of A.C. Motors," read before the Institution of Civil Engineers in 1898. The motor had shunt characteristics and formed the basis of other designs. At one time he advocated single-phase railway electrification, but whether the advent of mercury arc rectifiers changed his views we do not know.

Although Mr. Atkinson attained a high position on the technical side of the industry, he always had a strong bent towards the commercial side and, like many other technical men, he drifted in later years in that direction, marking a new epoch in his career. In conjunction with the late Mr. P. J. Fawcus he founded the Trafford Park Power and Light Supply Company, said to be the first company formed in this country with the primary object of distributing cheap power over an industrial area. For many years he was a director of that company, which about 1920 was absorbed by the Stretford Urban District Council. One of the electrical firms that built a factory at Trafford Park was that of W. T. Glover, and when that firm was reorganised in 1903 Mr. Atkinson became a director, a post which he held for about seventeen years, being for the greater part of that time in charge of the company's London office. From the time he joined the board of Glover and Co., Ltd., he had taken a prominent part in the affairs of the Cable Makers' Association, being at one time its Chairman. His exceptional abilities were therefore familiar to his associates, and on the death of Mr. A. H. Howard he was invited by his colleagues in the cable making industry to become the Secretary and Manager of the Association. Subsequently he became Director, retiring in 1936. He was also Chairman of the Joint Industrial Council of the Cable Making Industry, a member of the Wiring Rules Committee, and a past Chairman of the Royal Society of Arts.

In research he took a keen interest. From February 12th, 1926, to February, 1927, he was President of the British Electrical and Allied Industries Association. No one has served that Association better, and his remarks at the conclusion of his Presidential Address are characteristic of his zeal. Appealing for help, he said: "Any Government, any industrial leaders, who fail to see that research by Englishmen can accomplish any and every result, convict themselves of blindness, to lack of knowledge, and to lack of imagination. Research associations and research workers are not asking for charity; they are urging that the present squalid civilisation should be replaced, as it can be, by a far better one, if applied knowledge in every sphere is encouraged and developed, that instead of being a last charge upon the resources of the nation, research should be the first charge. We urge that the Press should make it part of its daily duty to inform its readers, in suitable but accurate terms, of the advances in knowledge that have been made, and are being made, of the progress that is possible, and of the immense economic advantage that must accrue and thus use its influence in creating an atmosphere driving Governments to action."

Mr. Atkinson never tired of relating his reminiscences and had many stories to tell of pioneer electrical engineers, most of whom he knew personally. Like the late Sir Thomas Callender he enjoyed speaking of the early difficulties the pioneers had in getting permission to lay electric light cables, and how they used to lay them without permission. When once they had been laid no one seemed to have had the power to make them take them up again. At the I.E.E. Commemoration meetings held in 1922 in celebration of the Institution's fiftieth year of existence, he was one of the most entertaining speakers. For the pioneers he displayed great admiration. Many of them, he said, were untrained men, or at any rate they had no training in the ordinary sense of the word. Thomas Parker was believed to have been in turn an ironmoulder, travelling showman, mesmerist, and finally an electrician.

To book writing he never seems to have turned his attention, but had he done so no one was better fitted to survey the industry's growth. From the early days of the dynamo and Jablochkoff candles he saw it expand to its present dimensions. That he was a great asset to the electrical industry, everyone who knew him will readily admit, and his passing will be deeply regretted by a wide circle of fellow-workers and friends.

E. P. BARFIELD

Mr. Eric P. Barfield, whose death occurred on August 7th, was one of the founders of Wild-Barfield Electric Furnaces, Ltd., managing director of the company since its incorporation in 1917, and chairman since last September, and was a director of its associated company, G.W.B. Electric Furnaces, Ltd. Mr. Barfield had always been associated with, and was a pioneer in the electrical industry. Commencing with the Edison and Swan Company, he joined the National Telephone Company, and was responsible for the installation of some of the first lead-covered paper-insulated telephone cables in the country, and at a very early age was manager of one of the largest South Coast telephone exchanges of that day. He then joined the head office staff of the General Electric Company, Ltd., and was subsequently intimately connected with the development of the Robertson lamp. Subsequently he went to Siemens Brothers to develop the manufacture and sale of the Tantalum lamp, the first metallic filament lamp to be introduced to the British market. Some years later, in conjunction with Mr. L. W. Wild, whom he had known for many years, he founded Automatic and Electric Furnaces, Ltd., and so formed the first company in this country to make industrial electric heat-treatment furnaces. Beginning with the manufacture of relatively small and specialised furnaces for the precision hardening of tools and gauges, the company gradually developed the larger furnaces, basing designs on the experience gained, until at the present day the company and its associate, G.W.B. Electric Furnaces, Ltd., construct resistance furnaces of all types. Mr. Barfield was actively associated with the company almost until his death, which occurred after a short illness of less than five weeks.

CHARLES MARTIN BURLS

Many of our readers associated with marine engineering will learn with deep regret of the death on Tuesday, August 1st, in a London nursing home of Mr. Charles Martin Burls, a partner of Burls, Gordon and Whiteford, marine consulting engineers and surveyors, of 4, Lloyd's Avenue, London, E.C.3. Mr. Burls, who was in his seventy-first year, was born in 1868, and served his apprenticeship with Maudslay, Sons and Field, of London. On the completion of his training he was engaged in various shipyards in connection with the erection of machinery in ships of the Royal Navy. He gained his sea experience in the Great Western Railway Company's steamers at Bristol, and later served in ships of John Holman and Son, obtaining his Extra First-class Board of Trade Engineer's Certificate in 1895. Two years later Mr. Burls began to practise as a consulting marine engineer with the firm of E. J. Caiger and Co., and afterwards founded his own firm of C. M. Burls, Gordon and Partners, which at a later date became Burls, Gordon and Whiteford. He was a member of the Institution of Civil Engineers and the Institution of Naval Architects, and a Fellow and one of the founder members of the Society of Consulting Marine Engineers and Surveyors, of which he was one of the three trustees. Mr. Burls was well known to shipowners and shipbuilding firms, and particularly in recent years was looked upon as an authority on marine engineering matters, his services as an expert witness in the High Courts of Justice and other Courts being frequently called upon.

Literature

Clyde and Other Coastal Steamers. By C. L. D. Duckworth, B.Sc., M. Inst. C.E., and G. E. Langmuir, M.A., LL.B. Glasgow: Brown, Son and Ferguson, Ltd. 1939. Pages 283. Price 12s. 6d. net.

There has always been a peculiar fascination about the Clyde and the notable vessels to be found plying its waters, from the days of the "Comet" onwards. The authors have already described the fleets of fast passenger steamers that carry thousands of passengers through all the seasons of the year with a regularity commonly associated with the railway. In another book they have dealt with the vessels serving the sparsely populated Western Highlands, whereas in this, their latest work, they are concerned with the less spectacular but equally useful craft that are engaged in coastal work and across the sea to Irish ports.

From an historical point of view it is useful to have a permanent record of these vessels, for many of the lines described have not taken the trouble to preserve the story of the ships they have operated; indeed, even in the work before us we notice certain gaps which it is hoped will be eventually filled.

The fleets described include Burns and Laird Lines, Coast Lines, Belfast Steamship Company, British and Irish Steam Packet Company, David MacBrayne, Clyde Shipping Company, and William Sloan and Co., each line being given a chapter, with the exception of the first named to which two are devoted. The last two chapters deal with various coastal companies no longer in existence, and Clyde coastal steamers of the present day, including the well-known little "puffers" which form such a characteristic feature of the Scottish lochs. In Appendix A over 100 pages are devoted to the fleet lists of the different companies, giving the principal dimensions and other particulars of the vessels described in the text. A perusal of these pages from an engineering point of view reveals the fact that practically every type of marine engine and propulsion is represented, but admittedly we should welcome rather more information relating to their machinery, boilers, &c., while service speeds might with advantage be included, although not of such great importance as in the case of cross-Channel packets. Interesting "family trees" of the shipping companies concerned are included, showing the dates at which each component company was absorbed, and thus many once-familiar lines have sunk into oblivion. In Appendix B will be found a complete list of the fleets of the respective companies.

It is somewhat of a mystery why certain steamers that neither have gone nor do go near Scottish waters are included (*e.g.*, the London and Channel Islands Steamship Company), but presumably it is for the purpose of maintaining a complete record of the ships owned by the respective companies. We can understand motor vessels being included in a work entitled "steamers," for lack of a simple comprehensive name for all mechanically propelled vessels. The way in which the oil engine is asserting itself is evident as we glance through this book.

Illustrations of a large number of the vessels add greatly to the value of a book which can be recommended to all who desire a complete record of the work done and the ships employed on important if not spectacular services. The descriptive text is very readable throughout.

SHORT NOTICES

Testing Television Sets. By J. H. Rayner. London: Chapman and Hall. 1938. Price 9s. 6d.—An endeavour is made by the author of this book to indicate the basis of testing television sets, whereby faults may be found by simple deduction, using the same methods suggested many years ago in his book on "Testing Radio Sets." The system can be adopted in the works, laboratory or on site, and the majority of tests that have to be made can be conducted with ordinary service apparatus. The book deals with all kinds of faults and their location, and forms a useful guide to those who may have to deal with troubles in television receiving apparatus. Attention is also paid to interference attributable to various causes, such as the ignition systems of motor vehicles, medical apparatus, &c.

Theory and Practice of Alternating Currents. By A. T. Dover. London: Sir Isaac Pitman. 1939. Price 18s.—New chapters on single-phase and three-phase transformers, polyphase alternators, three-phase induction motors, transmission circuits, and symmetrical components are included in the third edition of this volume. The original text has also been revised and the collection of examples, with answers, extended. These examples, which are additional to the worked examples in the text, now comprise 250 numeral selected and graded exercises, taken mainly from the examination papers of the university papers of the University of London (B.Sc. Eng.), the Institution of Electrical Engineers, and City and Guilds of London Institute, but exercises suitable for the National Certificate courses have also been included. In its revised form the volume is a useful addition to the text-books on alternating currents, covering as it does general principles, circuits, instruments, and measurements.

Alternating Current Bridge Methods. By B. Hague. London: Sir Isaac Pitman. 1938. Price 25s.—In preparing the fourth edition of this book three objects have been kept in view, namely, to insert the supplementary matter into its proper place in the text, to give an account of developments up to the end of 1937, and to expand certain matters that experience has shown to need further explanation. The result is a much enlarged and more fully illustrated volume, commensurate with the increased growth and importance of the subject. In dealing with the theoretical side of the subject the author has given a short account of circuit locus diagrams to explain their use in discussing sensitivity and balance convergence of bridge networks. Additions have also been made to the theory of bridges containing mutual inductance and to many minor points. A complete classification of bridges based on the work of Ferguson has also been included. As bridge apparatus has recently been considerably developed, a full account of modern tendencies is given, and in view of the wide use now made of oscillators, amplifiers, and detectors, particular attention is devoted to thermionic apparatus. New bridges and applications are described, whilst the treatment of some of the older methods has been extended. An extended and simplified classification of frequency bridges is also given. Because of its importance in high-frequency bridges and in response to the request of several correspondents, the subject of shielding now also receives consideration. Although radio frequency bridges fall outside the declared scope of the book, the author mentions them briefly.

BOOKS RECEIVED

What is Steel? Third edition. By L. Scheer. Translated by F. L. Meyenberg. London: Macdonald and Evans, 8, John Street, W.C.1. Price 6s. net.

Bridge Calculation and Design (for Steel Bridges). By D. Y. Hill, A.M. Inst. C.E. London: Charles Griffin and Co., Ltd., 42, Drury Lane, W.C.2. Price 25s. net.

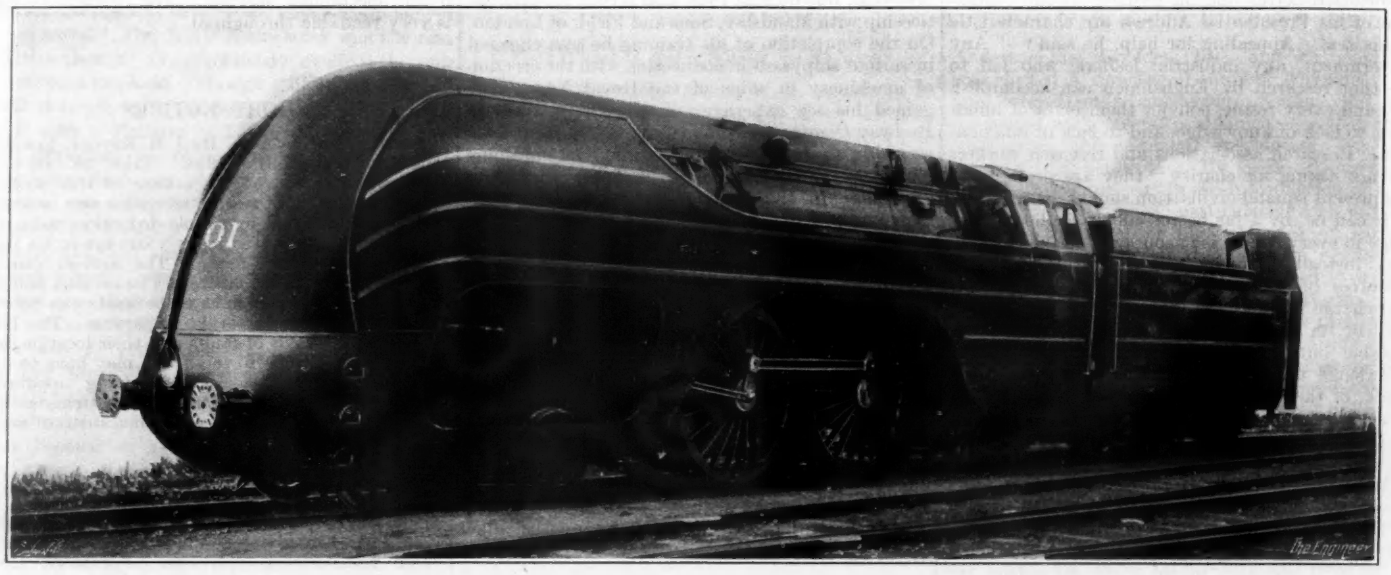
Motor Industry of Great Britain, 1939. London: Society of Motor Manufacturers and Traders, Ltd., Hobart House, Wilton Street, S.W.1. Price 5s. net.

Heating, Ventilation and Lighting of School Buildings. By W. Douglas Seymour. London: Oxford University Press, Amen House, Warwick Square, E.C.4. Price 12s. 6d. net.

Electrical Engineering Experiments: Theory and Practice. By H. R. Reed and G. F. Corcoran. London: Chapman and Hall, Ltd., 11, Henrietta Street, W.C.2. Price 12s. 6d. net.

The Complete Welder: Dealing with Up-to-date Methods of Gas and Electric Welding. Three volumes and chart case. London: George Newnes, Ltd., Tower House, Southampton Street, W.C.2. Price £3 5s. net.

BELGIAN NATIONAL RAILWAYS: STREAMLINED "ATLANTIC" ENGINE



Belgian "Atlantic" Locomotives

ON July 15th the Belgian National Railways began running two fast light trains between Brussels and Ostend in the even hour each way, including a stop at Bruges. The total distance is 71 miles, and on the down journey the 57·4 miles as far as Bruges are covered, start to stop, in 46 min., at an average speed of 74·6 m.p.h. The train is composed of first and second-class coaches only, and is made up of ordinary metallic coaching stock, the three to five coaches weighing empty 165 to 265 "tonnes." No extra fare is charged for seats in the train. The "Atlantic" type of locomotive has been adopted. The maximum speed in service is 93 m.p.h., although the locomotives can easily reach 99 with the weights quoted above. The line has continuous up-gradients of 1 in 200 for the first half dozen miles and similar down gradients beyond; further on, it is an easy one, barring junctions and station crossings, such as at Ghent.

Six of the locomotives used for these trains have been built by the Cockerill works of Seraing, four having Walschaerts' valve gear, one the Dabeg, and the sixth the Caprotti. The driving wheels have a diameter of 6ft. 10⅝in., comparable with the 7ft. of the "Hiawatha" class of locomotive. The angular speed of the revolving parts is thus limited to 380 r.p.m., which is low. The wheel base measures over 32ft. 5¾in., of which 7ft. 6in. is rigid. The diameter of the trailing wheels is 4ft. 1⅛in. and of the bogey wheels 2ft. 11⅜in.

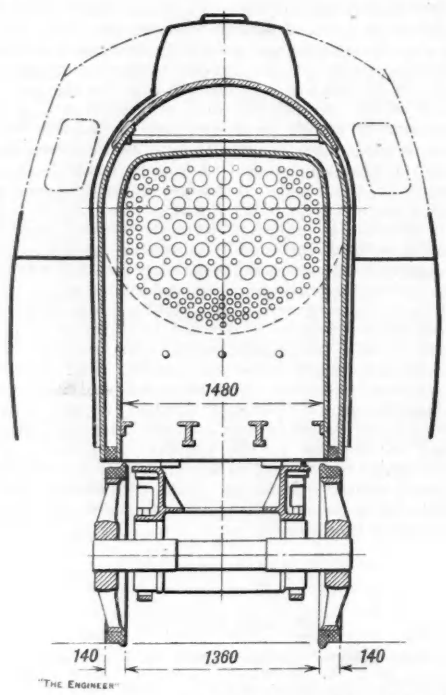
The engines have two inside cylinders, and the valves of the locomotives having Walschaerts' gear have a diameter two-thirds that of the cylinders. In the Dabeg and Caprotti engines the weight of the moving equipment is about 11 lb. In the four others the weight of the gear does not exceed 150 lb.

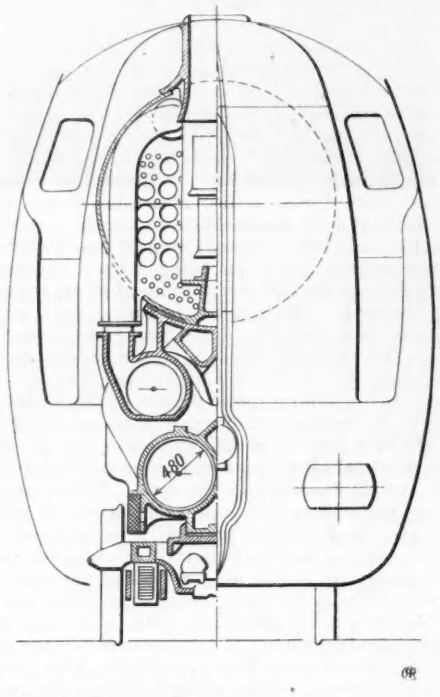
The steam pressure is 256 lb. per square inch. The boiler plates are of nickel steel, with a nickel percentage of 2 per cent. The engines develop a tractive effort of 23,510 lb. at 65 per cent. mean pressure, or 26,643 lb. if calculated at 85 per cent. The heating surface is 1728 square feet, to which has to be added 678 square feet for the superheater, which is designed to give 880 deg. Fah. superheat. The grate area is 40 square feet.

The locomotives, we are informed, burn about 4850 lb. of coal when developing 2200 I.H.P. They have been fitted with "Pyram" smoke mixers, and "Superior" tube cleaners for use when running. There are two Metcalfe injectors, one of the waste steam and the other of the hot water type.

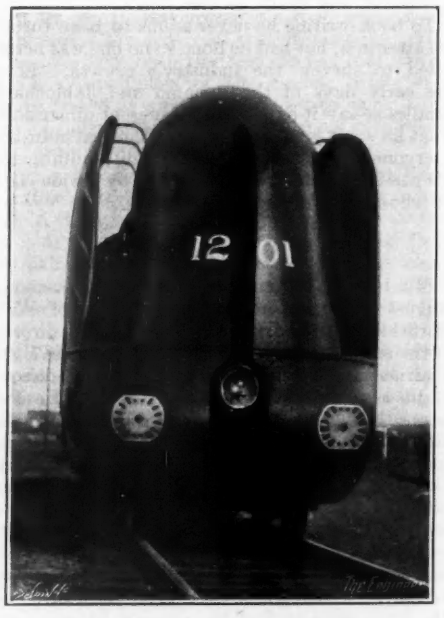
As in previous classes, the locomotives have double chimneys. The fore part of the boiler rests on the cylinder casting and the back on a steel casting. Intermediate flexible sheets fix it to the main frame. The locomotives have bar frames; the bogie frame is cast in a single piece. Partial streamlining on the Huet system has been applied both to the engine and tender. As usual, the front has a vertical aperture which creates a calm zone around the moving parts. Although covering is omitted where accessibility is essential, this system of streamlining has, it is claimed, proved efficient.

Owing to the shortness of the run, normal six-wheel tenders carrying 24,000 gallons of water and 7·5 tons of coal are used. In working order the locomotives weigh 87 tons, 45½ tons being available for adhesion. The tenders weigh 58 tons. The weight of the locomotives when empty is 78·5 English tons. It is too early as yet to give average figures for the coal and oil consumption, but in spite of signal checks, the trains usually arrive at Bruges before time, and even when leaving 30 sec. to 60 sec. late, owing to traffic contingencies, get to their destination on time.





SECTION THROUGH FIREBOX AND CYLINDERS



FRONT VIEW OF ENGINE

Electricity in Indian Irrigation

IN a "Rural Power" Supplement to the issue of May 24th, the Calcutta *Statesman* published a number of articles relating to changes of a far-reaching character which are being brought about in India by the grid distribution of electricity. The most important use of the power rendered available in rural areas, and largely provided especially for such areas, is in pumping irrigation water from existing wells, from channels delivering water at levels below the surface of the adjacent land and, on a large scale, from tube wells of very considerable depths.

Two of the articles, one consisting of extracts from a paper by Sir William Stampe, read before the East India Association, and the other contributed by Mr. R. G. Allan, C.I.E., Commissioner of Agriculture, Baroda, especially attract attention by reason of their explanation of the agricultural and economic situation, exposition of the character of

the development as related to local and regional conditions, and discussion of factors to be taken into consideration with respect to further use of the grids.

The articles are of considerable length and they contain explanations of the situation, general or regional, with respect to the peasants, private enterprise, finance, and the grid systems provided by Governments.

A few main points are presented, hereunder, in the form of reproductions or summaries of passages in the texts.

Revitalising the Indian Countryside

From Mr. R. G. Allan's article we learn that the standard of farming is, throughout India, dependent on the security of the crop. Irrigation of any kind not only provides this security, but, if perennial, permits of cropping throughout the year, thus neutralising the disability of farming in a country in which the rainfall is seasonal. If the cultivator were provided with a reasonable supply of water throughout the year, at least 75 per cent. of the need to discover and invent cottage industries, for which he has no great liking or aptitude, would not exist.

Until recent years Governments have almost entirely confined their provision of irrigation waters to those derived from surface supplies, while the development of underground water supplies, left to private landowners, has almost entirely been restricted to tapping the upper layers of such supplies. The coming of cheap electric power has revolutionised the position. The State-controlled tube well becomes a possibility when cheap power can be brought to places where there are sufficient supplies of water within 300ft. of the surface.

Areas in the United Provinces which five years ago largely grew only a precarious crop of *bajra* (spiked millet; *panicillaria spicata*), and similar quick-maturing monsoon crops, and on which agricultural work was restricted to a few weeks in the year, now grow sugar cane, winter crops, and fodder crops without let or hindrance.

Limiting Conditions

The tube well should be provided where normal wells are absent or defective, not usually where ample water supplies have for long been utilised by numerous wells, although cheap power can readily and effectively be used to lift water under such circumstances. Where the capacity of a well is 2000 gallons or less per hour, or the holding making use of the water is seven acres or less, it is on the whole uneconomic to replace the bullock by other forms of power; but where those limits are exceeded replacement of a part of the bullock power of the farm by some other form is economical. For that purpose nothing calls for less capital investment than an electric pump, or is so convenient and unlikely to cause trouble, provided the power cost not more than 1 anna per unit.

Advantages: Wasteful Practices

Advantages of the introduction of tube well irrigation include consolidation of cropping, better means for the maintenance of livestock, and improvement of milk supplies, while the use of electric pumping from ordinary wells reduces the numbers of bullocks on a farm, or releases them for employment in tillage or carting.

A tube well of standard output can irrigate up to 100 acres of sugar cane or 240 acres of wheat. It often fails to function with the efficiency of a private well because the area which is given pre-sowing irrigation is larger than can be maintained when the growing crops make their full demand. Despite that practice and other abuses of the system or failure, as yet, to provide adequate administrative control, the tube well system in the United Provinces has fully justified its creation. Moreover, cheap power, easily secured and applied, can play a part in developing the countryside, as in small village industries, such as bone crushing for the production of a fertiliser; oilseed crushing and the utilisation of the proportion of the sugar-cane crop not taken by the factories.

Dawn of a Cheap Power Area

In Sir William Stampe's article it is stated that prior to the introduction of systematic irrigation in India, water could only be lifted from wells of varying depths by animal or manual power. The advent of the so-called "gravity" canal system led to the displacement of millions of cattle and men from that service. In spite of this fact, if a census were taken it would probably be found that there are now not less but more cattle in the areas so irrigated. Larger areas are cultivated, there is double cropping, and the better-class crops now being grown require more animal and manual labour for their cultivation and transport.

Functions of a Grid

Before the widespread electrification of the rural area served by the Ganges grid, the water of a certain canal, flowing a few feet below the level of the surrounding fields, had to be raised by "bhokas," baskets swung on a rope held by two men. Thousands of men were engaged yearly in that tract alone on this work. When cheap electricity, generated at adjacent canal falls, became available, the proposal to pump the water to a raised channel commanding the fields—the charge per acre for the water to to be doubled—received an 80 per cent. vote of the villagers concerned, when a referendum was taken.

On the Ganges grid in the United Provinces, the demand in fifty out of the eighty-eight towns connected to the system could not have justified the installation of local plants for many years to come—if ever. Large agricultural areas would never have known the advantage of cheap electricity, nor would the vast tube well irrigation system have been possible.

In the Punjab and Madras

The grid supplies power to scores of small brassware factories, and to flour mills, replacing cottage hand mills. In the Punjab and Madras, where electric grid systems are in successful operation, cotton spinning and weaving mills, large and small, as well as cottage hosiery plants, are rapidly being connected. In Madras, general electrification of the towns, the larger villages, and coffee and tea plantations is proceeding under the Pykara project with its associated schemes of steam and water power development, and the River Cauvery, which supplies power for Mysore State, is being further harnessed to supplement the Pykara system.

The Ganges Grid: United Provinces

In the United Provinces the Ganges Canal grid system, for which, in stages of one or two at a time, seven canal falls have been utilised, provides power from sources nearer the field of utilisation than is usual, and serves 12,000 square miles of agricultural lands. The current generated at the seven falls is transformed to 66,000 volts and carried to more than eighty towns and 2000 village sub-stations. A large steam station at Chandausi brings the total power available to 29,000 kW, about half of which is used for irrigation pumping from rivers and tube wells, and for agriculture generally, about one-tenth for domestic purposes and two-fifths for urban industries.

Spaced roughly about 1½ miles apart, each in the middle of some 250 acres of crops, are the State tube wells with their sub-stations connected to the 11,000 volts feeder lines. They number nearly 1500.

Cost of the Grid System and of the Tube Wells

The cost of the Ganges grid system, Rs. 1204 per kilowatt, includes the provision of 4140 miles of high-tension lines and 1600 sub-stations. The average all-in cost of 8 pies, or ¾d., per unit delivered at scattered points cannot fairly be compared with the figure of a ¼ anna (3 pies) per unit, which is commercially possible in concentrated industrial areas. One might as well compare the cost of coal at the pit's mouth with that of coal delivered at house kitchens. The capital cost of the system, Rs. 348 lakhs, or, roughly, £3,000,000, has already ceased to be a dead charge on the Province, as a net return of some 4 lakhs was forthcoming in 1937, after meeting interest, depreciation, and working expenses, and the figure is increasing as the load develops.

Turning to the finance of the less mature tube wells scheme, the return has, naturally, not yet proved so favourable. The capital cost of some 1500 tube wells, with their equipment, buildings, and approach roads, is roughly Rs. 135 lakhs, or £700 per well of 30,000 gallons per hour yield.

Description of the Tube Wells

In an article by Mr. L. E. Dawson, I.S.E., it is stated that a number of tube wells of different sizes and design were put down by the United Provinces Irrigation Department in 1931, and the data regarding initial costs, operating charges, hours of pumping, and so forth, have been collected and analysed. In the next three years ninety-five experimental tube wells were installed, their discharges varying from 15,000 to 70,000 gallons per hour. Eventually, it was decided to provide 1½ cusecs (about 33,000 gallons per hour) wells and to space them so that each should command about 1½ square miles. In the summer of 1934 a programme for the sinking of 1500 tube wells was drawn up.

The standard tube well consists of a 6in. bore sunk some 250ft. Subsoil water enters the bore through 100ft. of strainer, situated in the sandy strata, the remaining 150ft., in passing through clays, being ordinary 6in. pipe.

At the spring level, 10ft. to 42ft. below ground surface, a centrifugal pump, direct coupled to a 12½ H.P. A.C. motor, is installed. Each pair of wells has a transformer which brings the current down from 11,000 volts to 440 volts. In some seventy wells, where the spring level is very low, bore-hole pumps of 10, 15, or 21 H.P. have been installed.

Water is discharged through a vee-notch measuring weir into distributing channels, usually 2½ miles long, the first mile of which is lined with brick masonry or cement concrete. Cultivators are charged at rates ranging from 1 anna 1 pie to 2 annas 9 pies per unit of electricity, the share taken by the grid being 9 pies.

England's Metatechnical Tragedie

Herr Emil Jung contributes to *Rundschau Deutscher Technik* of July 20th an article entitled "England's metatechnische Tragödie," which we reprint below. With a view, presumably, of impressing English readers it is translated into our tongue. The gist of it appears to be that whilst democracy is a very suitable political system for an agrarian State, nothing but authoritarian government can bring out the best qualities of a technical or industrial State.

We suggest with all politeness to the Editor of *Rundschau Deutscher Technik* that if it was his sincere wish to make his contributor's argument clear to English-speaking people, he would have been well advised to obtain the services of a translator who had better command of the English language. As it stands, much of the argument is obscured by poor translation.

We may add that whilst the prefix "meta" may convey something to the German mind, in this connection it will leave English people groping for its sense. Always a difficult prefix—implying, as it may, "between, with, after, behind, over, about, reversely, &c.," its meaning in association with "technical" is hard to define.

During the present political high tension above all England is subject to all discussions. The reason for that is so evident, that it may be useless to loss any word.

But in all these deliberations one point is overlooked; the technical basis of Englands development and even more the functional, i. e. the metatechnical relations, which, however, would have to become so significant, even decisive, particularly to England.

The fact, that this manner of meditation is strange also in England or were unable to prevail, is in plain words Englands metatechnical tragedy. Only when this will be duly comprehended in England, one can reckon with a fundamental turning of England to a right development in future.

*

Until abt. 1800, also in England the field has been the centre of all life, above all also of the economical and political life. The harvest got in in general only once per year decided during millenniums the rhythme of this life, which was characterised by uniformity, i. e. in a certain measure static elements of development prevailed.

In consequence of this development also in England a static administration arose and in close connection with it democratic forms of the political direction of the State and also of the people. The peerage, the feudal manors consequently must become the leading men of England, who neverthless were farsighted enough to tolerate the introduction of the parlamentary system.

The great revolution, the change of the existing technical development, which opened entirely new spheres of labour and enabled a certain solution from the natural connections to a high degree, emanated towards 1800 from English (Germanic) heads.

With the new steam engine new machine—tools and textile machines were developed, which gave a new character to the whole trade. Definitely decisive for the "new" of that time were, however, at first the locomotive and the steamship, for then a new factory could arise, which the contrary to the field in every respect.

In this way England had created all tools in order to build up a pertinent new world, which had all conditions to disconnect out of the life of the mankind the casual event to which it was so devoted. Then indeed the century of the liberty, equality and fraternity, the dream of the French people, could have started*).

In England, however, somewhat curious became manifest. As if one were entirely exhausted by the great mass of the inventions at the beginning of the 19th century, one let over to the other nations to develop the English germs, in the later decades, abt. still at 1830. Particularly the United States of America have acted this part, though only on the purely mechanical side.

In England the technical progresses were used only for materialistic purposes. Loosened from the conditions given by the nature, particularly from the harvest happening but once in the year, the factory multiplied the turnovers, and the so-called economic liberalism celebrated in plain words triumphes. In political and social respect that time was a complete failure in England, so far as the consequences of the technical suppositions were in question.

Apparently England seemed to follow the technical development, as shown by the enlargement of the Navy or by the methodic erection of coal—and later on of oil stations. The pure agrarian State has become a State of industry, and the dimensional difference of both forms of State were

*) We are desisting from dealing with these connections — 150 years after the "great" French revolution, but they are resulting quite positively from the explanation of the characteristics of the development.

overlooked. The static agrarian State can be administrated by democracy, the dynamic State of industrie, however, is to be „carried on", i. e. must be conducted.

The Englishmen have overlooked this self understood point of exact thinking. Therefore they speak in matters of politics another dimensional language than the autoritarian States, quite different particularly to the national socialist Germany, which just now is about to draw the decisive synthesis between the agrarian State and the State of Industry, or commonly said, to transpose the resultant from the static and dynamic components of the development in facts.

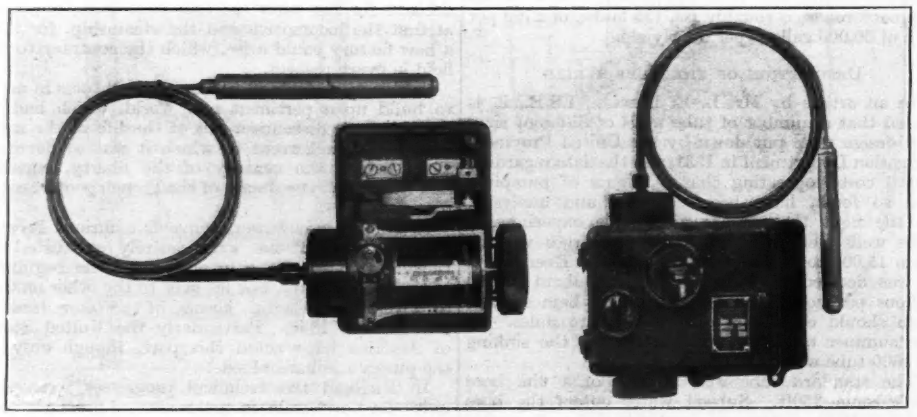
This would have been Englands historic world mission. Unfortunately England has not realised this mission. Through her failure the occident fell in a state of despair and hopelessness, which up to now only and exclusively has been surmounted in the autoritarian States, i. e. by regimes, against which England unprecedentedly struggles. These States, however, have only done what England has neglected.

England and the so-called democratic States must, by the herewith mentioned reasons conditioned by their fortune, accept the forms of life, as already introduced by the autoritarian States. The later that happens, the worse and sorrier must this be for the world. To have neglected up to now already important things and to be unable to recognise the real basis of the most important questions of our time dealt with in this article, that is expressed in fair words: Englands metatechnical tragedy.

Duct and Immersion Thermostats

We have received from the British Thermostat Company, Ltd., of Windmill Road, Sunbury-on-Thames, Middlesex, particulars of thermostats for controlling the temperature of air in the ducts and trunking of heating and air conditioning installations, for controlling the temperature in rooms, cold chambers and drying ovens, and in certain circumstances for use as immersion thermostats for controlling the temperature of vessels containing liquids. They operate on the vapour pressure principle, and consist of a metallic bulb or phial charged with volatile liquid and connected by capillary tubing to seamless metallic bellows. Change of temperature at the phial results in a corresponding change of vapour pressure in the charged system, causing the bellows to expand or contract. Movement of the bellows operates a switch against spring pressure, which can be adjusted to preset the temperature at which the control operates.

When used as air duct thermostats, the instruments may be arranged to switch electric heaters, motorised valves controlling the flow to hot water or steam coils, cooling units, or for the operation of damper motors. The instruments can be employed as room thermostats in refrigeration and cold storage plants, drying cabinets, and in other situations where it is desirable to have the switch mechanism outside the space to be controlled or at some distance from the sensitive element. Thermostats, such as those shown in the illustration, are suitable for controlling heated vessels and industrial processes. These thermostats also find application as water temperature limit thermostats in central heating systems, using hot water boilers. In such installations the main control is on the space temperature, the immersion thermostat being employed merely as a safety device.

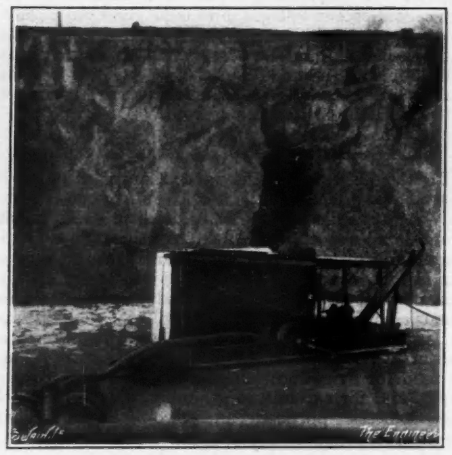


DUCT AND IMMERSION THERMOSTATS

The movement is robustly constructed, and is contained in a neat bakelite case with top cable entry. The temperature scale is visible through a window in the front, and the temperature setting can be adjusted by a knob. While there are standard temperature ranges and differentials, instruments can be supplied for other ranges to order. The switch assembly has open silver contacts and a magnetically assisted snap action. It is rated to break 10 amperes A.C. or 5 amperes D.C. on non-inductive load at 250 volts. For heavier loads or on 400 volts, the thermostats should be employed for energising relay circuits only. Normally, the thermostats are fitted with 5ft. of capillary tube, but longer tubes can be fitted to order It is recommended that the total length should not exceed 20ft.

A Motor-Driven Gravel Pump

An unusual application of an electric motor has been brought to our notice by Higgs Motors, Ltd., of Witton, Birmingham. A pump, to which the motor is directly coupled, is used to obtain gravel from a permanently flooded pit, in which the pump and motor are mounted on a floating pontoon. The motor is a 50 H.P., 750 r.p.m., 400-volt, 50-cycle, three-phase Higgs machine, and the pump a Blackstone unchokeable unit, especially designed for pumping gravel. The normal suction lift is 10ft., and the delivery 15ft. along 45ft. of 5in. piping. Normally the pump delivers 900 gallons of mixture per minute, containing 10 per cent. of solids. As the level of the gravel in the floor of the pit is lowered, the suction lift increases to about 18ft., and with this lift the delivery is about 750 gallons per minute. By moving the complete pumping unit on its floating pontoon, the floor of the pit is kept more or less level. The installation was carried out by H. Noble, of Carshalton Road, Lakenham, Norwich, for Thorp Gravel Pits, Harvey Lane, Norwich.



GRAVEL PUMP PONTOON

Recording Lightning Strokes

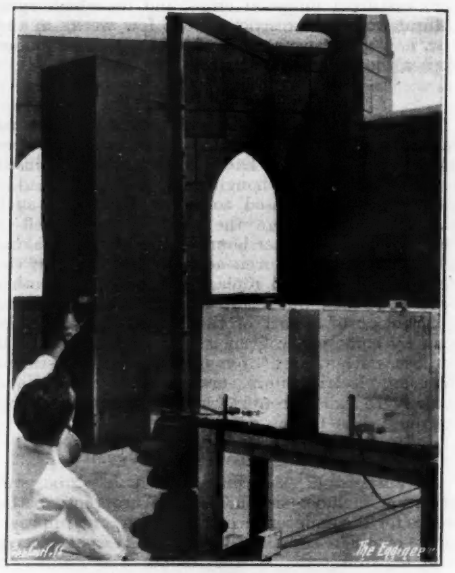
Within twenty-four hours after the engineers had made final preparations for the reception of lightning on the roof of the 42-storey Cathedral of Learning of the University of Pittsburg, a direct stroke of lightning was received and fully recorded. Its presence gave Westinghouse engineers two opportunities they had been eagerly awaiting—to try their newly developed device for recording a current in a lightning stroke throughout its entirety, and to determine if a new type of lighning arrester can withstand direct strokes. Both opportunities were realised with complete satisfaction. A direct stroke of lightning was recorded for the first time in its entirety, including the initial high-current surge and the long-lasting, low-current tail. The full current of this stroke passed through a standard "Autovalve" lightning arrester with no damage to it. This is also the first known instance in America of a lightning arrester experiencing a direct stroke without injury.

The lightning observation station on the roof of the Cathedral of Learning is but one of several established over the country in regions of greatest lightning severity. This is part of an extensive investigation of direct lightning strokes, and makes use of a new rotating automatic surge-recording device, recently developed by the Westinghouse Company.

Investigation stations have been placed on the power lines of four major undertakings in the south-eastern part of the United States. These stations were carefully selected as being in regions of particularly severe lightning activity, and as having lines providing high insulation strength to obtain the worst conditions of surge as far as electrical apparatus is concerned. Nineteen stations have been provided on these lines, which cover a range from 4600 volts to 110 kV. They include a total of forty of the rotating recorders. In addition, are the two units on the Cathedral of Learning, four units installed at the radio station KDKA transmitter at Saxonburg, Pa., and twelve more are expected to be placed on the lines of undertakings in the north central region. The total number of surge recorders at stations widely distributed over the eastern half of the United States during the present lightning season will be well over sixty.

The development of a simple, relatively inexpensive surge recording device is a long step forward in the development of lightning-proof lines and equipment. Many records of complete lightning strokes can now be obtained in a short time. With the knowledge of the full characteristics of lightning, builders of lines and protective devices are greatly aided in their efforts to create systems invulnerable to direct strokes.

A portion of the apparatus used at Pittsburg is shown in the illustration, including the lower portion of the 50ft. mast on its porcelain insulator base, and two rotating surge recorders in steel enclosures. In the open wooden cabinet is the "Autovalve" lightning arrester, which successfully received the direct lightning stroke.



PART OF PITTSBURG LIGHTNING APPARATUS

Heaton Works Journal

To celebrate the fiftieth year of their existence, C. A. Parsons and Co., Ltd., have made a special number of the *Heaton Works Journal*. The issue contains the works and personal news as usual, and, also as usual, several attractive articles which have nothing to do with engineering, and are none the worse for that. There are also some exceptionally good landscape photographs and a few technical articles. But all these things are no more than the bezel for the jewel of the *Journal*, a symposium by several eminent hands, entitled "Reminiscences," in which each of the authors records his own recollections of Sir Charles Parsons.

The first story is by Frank Hodgkinson, who in 1895 was sent from the Heaton Works to aid in the design and construction of turbines at Pittsburg, Westinghouse just having secured a licence. Mr. Hodgkinson has a great deal to say about the development of the steam turbine in America, and tells several tales about Sir Charles anent his absent-mindedness. his peculiar methods of calculation, the simplicity of his experimental methods, and so on. The next author is Mr. J. H. Bruce, who was for many years engineer to the Parsons Foreign Patents Company, Ltd. In his anecdotes he also touches upon Sir Charles' ability for mixing science and empiricism, and getting the right answer.

Reminiscences by two of Sir Charles' nephews, the

Hon. Geoffrey Parsons (chairman of the Parsons Marine Steam Turbine Company, Ltd.), and Mr. Arthur Parsons (a director of Ross, Ltd.), follow. The first contains a letter written by Sir Charles to his brother Lawrence in 1894, which has not been published before, and is valuable owing to the fact that it throws a little new light on the "Turbinia." Arthur Parsons' is perhaps the most "domestic" of the essays. It is full of delightful little homely tales about Sir Charles, in all of which the writer himself figures. They help us to see Sir Charles as he was, amongst his own people; his kindliness as well as his "peppery" side. One of the best of the anecdotes turns upon the appearance of a mysterious lady at Sir Charles' dinner table. When at length he found out who she was, he was so put out because he had not been told that she had been invited, that he declared to Arthur Parsons he would not return to the drawing-room. Arthur persuaded him to find an adequate excuse, whereupon Parsons betook himself to the engine house and so manipulated the voltage rheostat that all the lights in the house staggered up and down several times before returning to normal. Then he escaped to his room, where he was shortly joined by his nephew, who had expressed his opinion in the drawing-room that soot had got on the plugs, that his uncle was personally attending to them, and that it was his duty to give him a hand.

Amongst the other contributors to the symposium are Mr. C. A. Holbrow, Mr. W. B. Harvey, Mr. C. Turnbull, Mr. H. H. Law, Mr. John H. Barker (at one time general manager at Heaton), and last but by no means least, Mr. F. G. H. Bedford (chairman and managing director of the company and a very old and intimate friend of the great inventor). Mr. Bedford has many delightful tales, one of which we must quote: "At breakfast he might frequently be seen eating toast and marmalade with a boiled egg, and one also recalls the story of his coming down late for breakfast at the house of a friend in Northumberland, and, finding the dishes empty, proceeding cheerfully to eat the scraps that had been collected on a plate for the dogs, and apparently enjoying them so much that he returned for more."

This collection of anecdotes, technical and personal, forms a very valuable addition to the biography of the greatest inventor of the nineteenth century, and will be invaluable to all those who, fifty years hence, endeavour to write his "Life." What if some of them may be apocryphal or "decorated"? Are they any the worse if they show the true character of the man?

One further excellence of this remarkable number of the *Heaton Works Journal* is that it includes an admirable reproduction in colours of Orpen's well-known portrait of Sir Charles.

Sixty Years Ago

The Eudromon

It is well known that the military "tank" evolved during the Great War and now the parent of a numerous progeny of vehicles in use by the modern mechanised army, was itself the descendant of a long line of ancestors of the chain-track tractor family. The first vehicle of that type which can be traced was Edgeworth's "portable railway" carriage of 1770. Many other inventions of a similar nature succeeded it, but few, if any, gave a good account of themselves in practice until Boydell produced his traction engine with bearing plates surrounding the driving wheels, the plates being so arranged that they were laid down on the ground one after another to form a continuous railway for the wheels. Boydell's original patent was dated 1846 and in 1854 he took out a second patent embodying a number of improvements. There can be no doubt that Boydell's tractor was tried in practice, and that it gave a considerable measure of satisfaction. It was not, strictly speaking, a chain-track tractor; the bearing plates were associated solely with the two driving wheels and were laid down and lifted by the driving wheels as they rotated. Even before Boydell's time, however, many inventors had developed the idea of the true chain-track tractor, in which the track in the form of an endless chain of links or plates passes under and over the driving wheels and round guiding wheels near one or both ends of the vehicle. There is some evidence to suggest that Edgeworth's early vehicle was of this actual type. If any reader should still have a doubt as to the antiquity of the chain-track tractor, he may consult our issue of August 15th, 1879, in which he will find illustrated and described a "tram-plate wagon," or "Eudromon," as the inventor called it, which was exhibited by Mr. W. C. Pellatt, of Clerkenwell, at that year's Royal Agricultural Society's Show at Finsbury. We described the vehicle—a 7 or 8-ton farm wagon—as being fitted with "a continuous self-laying and self-adjusting tramway on the principle of Boydell's railway, but differently carried out." The tramway or track was composed of hardwood plates faced with iron and attached to two endless chains. The tracks, one on each side of the vehicle, passed under and over the road wheels and round three guide rollers, one at each end of the vehicle and one midway between the wheels, and raised up above their level. It was stated that freedom was given to the chains and tram plates to permit the vehicle to be moved round curves. Mr. Pellatt also exhibited the invention applied to a small four-wheeled open van, for goods or passengers, suitable for high speed. He intended to make arrangements for applying the invention to tram cars, but we expressed the opinion that it would not answer for that purpose.

Tests of Welded Rail Joints

Studies of rails and rail joints in many practical and economic aspects, at the mill or shop, in the laboratory, and on the permanent way, have been in progress for some years by the American Railway Engineering Association, the laboratory work being carried out at the engineering experiment station of the University of Illinois. The most recent phase of the study is an investigation of the character and quality of welded rail joints. A preliminary report on this subject points out that the occasional occurrence of a poor weld must be recognised, but that there is no reliable non-destructive test for poor welds, and little, if any, information as to the probable frequency of such welds. This situation, as well as the relative seriousness of failure of bolted fish-plate joints and welded joints, must enter into consideration in deciding whether or not to use welded rails in track. In considering the results of tests two bases of comparison are to be kept in mind: first, the comparison between welded joints and the ordinary bolted fish-plate joints as to strength, toughness, durability, and wearing qualities; secondly, the comparison between the welded joint and the adjacent solid or original rail.

Eventually a considerable amount of field study of welded joints will be necessary, but so far the work has been mainly in the laboratory and has been conducted along the following lines:—Firstly, etch tests of specimens from welded joints made by various processes, in order to find whether flakes, laps, holes, burns, inclusions, cracks, or any other types of defects have formed during the process of welding and subsequent cooling; and, if so, in what part of the joint these defects are situated. Secondly, hardness surveys of the metal in the weld, the adjacent rail, and the heat-affected transition zone between the weld and the rail. Thirdly, surveys of typical crystalline structure in weld, rail, and transition zone by means of the metallographic microscope. Fourthly, chemical analyses of the metal in the same three parts. Fifthly, mechanical tests of specimens cut from the parts; these tests include tension, impact, and fatigue tests. Sixthly, rolling load fatigue tests of full-size specimens of welded rails to determine whether internal fissures can be developed in welded joints, to determine their fatigue strength in flexure, and to determine the likelihood of damage to the web of the rail near the weld. Seventhly, drop tests and bend tests of full-sized rail joints.

Test rails of 112 lb. and 131 lb. flanged section have been welded by five different processes:—(*a*) A gas fusion welding process operated by two men, one on each side; (*b*) a gas fusion welding process operated by one man; (*c*) the thermit process; (*d*) electric flash pressure butt welding; (*e*) gas-heated pressure butt welding process.

Etched specimens sliced horizontally at $\frac{1}{16}$in. below the top of the rail head have shown evidence of inclusions, laps, bending of the fibre of the metal, and some crack-like markings. How much damage they do is uncertain, but actual cracks may act as nuclei for the spread of fissures or other fatigue cracks. It is obvious that the macrostructure of the steel in and near the weld has been changed from that in the rail. Specimens from welds by the gas fusion process and the thermit process show more ferrite and larger grains than those from the two pressure butt welding processes.

For determining the relative hardness of metal in the rail, the weld metal, and the heat-affected area, the Rockwell-C test was used, as the small indentations made by the diamond cone point detect more localised spots of hard and soft metal than the larger indentations of the steel ball in the Brinell test. The general results of the tests are given in Table I, and it will be noted that in the weld by the gas fusion process (*b*) the weld metal was distinctly harder than the rail steel. This condition is attributed to the composition of the welding rod, which is noted in Table II. In general, it is considered desirable to have the weld of about the same hardness as the rail in order to equalise wear along the track and to avoid hard or soft spots in the continuous rail. Analyses of the rails and welding rods are given in Table II.

Specimens for the usual mechanical tests—tension, impact tension, and fatigue—were cut from the weld, the heat-affected zone and the body of the rail. For all the joints these tests have indicated a rather wide variety in the quality of metal in the joint as welded. Practically none of this metal reached values equal to those of the rail steel.

For the rolling-load tests the welded joint was put in a testing machine where a loaded wheel rolled back and forth upon the rail. The joint was required to sustain without fracture a limiting or minimum number of 2,000,000 applications of the load. Failure under such loading may be due to the following three causes, all of which have occurred during these tests:—Firstly, as the result of repeated flexural stresses, in which case it is usually the tensile stress that causes failure; secondly, as the result of repeated shearing stress in the web of the rail, and this stress depends upon wheel load rather than bending moment; thirdly, by the development of internal fissures starting at minute imperfections and caused by the heavy stresses directly under the wheel load. These rolling load tests are in progress, but some joints failed to stand even the prescribed minimum number of loadings. One indication, however, is that welded joints may be strengthened by being subjected to many cycles of stress below the fatigue limit of the original method.

In drop tests with a 1-ton tup or hammer falling 20ft. or 22ft., only the electric flash-welded joints met the requirement of sustaining one blow without fracture. All the others broke under the first blow. In bend tests maximum loads carried before fracture were as follows:—Gas fusion welds, 168,500 lb., with 0·53in. deflection; thermit welds, 231,500 lb. and 1·65in. deflection; electric flash weld, 315,000 lb., with 5·98in. deflection; gas-heated butt weld, 239,200 lb., with 4·70in. deflection. Steel rails thus tested have carried 225,000 lb. and 300,000 lb., with 4in. and 5in. deflection.

Table I.—*Hardness Tests on Welded Joints.*

Type of weld joint.	Weight of rail, pounds per yard.	Rockwell—C numbers.								
		Rail.			Heat-affected zone.			Weld metal.		
		Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.
(*a*) Gas fusion	112	21	22	24	13	21	25	13	22	30
(*b*) Gas fusion	131	22	23	24	17	26	29	28	31	37
(*c*) Thermit	112	21	23	24	19	24	26	16	22	26
(*c*) Thermit	131	20	22	24	23	27	29	10	25	28
(*d*) Electric flash	131	21	23	24	27	28	30	27	30	32
(*e*) Gas heat pressure	112	21	23	24	16	20	24	17	25	28

Table II.—*Analyses of Rails and Welding Rods.*

	Carbon.	Manganese.	Phosphorus.	Sulphur.	Silicon.	Chromium.	Vanadium.
Rails:							
112 lb.	0·70	0·76	0·020	0·024	0·19	—	—
(*c*) 112 lb. (gas heat weld)	0·73	0·80	0·020	0·022	0·20	—	—
131 lb.	0·71	0·81	0·023	0·037	0·15	—	—
Rods:							
Process (*a*), gas	0·45–0·50	1·00	—	—	0·45	1·00	—
Process (*b*), gas	0·20–0·40	0·85–1·15	0·035	0·04	0·15	0·9–1·25	0·10–0·30
Process (*c*), Thermit	0·41	0·74	0·036	0·058	0·044	—	—

Electrical Fair Trading Council.—The Fair Trading Council has issued in pocket size form a booklet of its policy with all amendments to date. In reissuing the policy in this form, the Council hopes that the publication will commend itself to all who are concerned in the manufacture and/or distribution of electrical products within the scope of the policies, aims, and objects, as a convenient booklet which every member of its relevant personnel can carry about with him as a constant work of reference on all commercial matters that are appropriate. It is also hoped that the manufacturers and distributors concerned, throughout the country, will find it possible, if they have not already done so, to adopt the policy and to issue the publication to respective staffs as definite instructions. A large number of copies will be distributed during the next few weeks, but in the meantime any firm which is directly concerned is invited to apply to the Council's office, Kern House, Kingsway, W.C.2, for a specimen copy, which will be sent free of charge. Alternately, any quantity of the publication can be obtained by approved firms on application, at the cost of 2s. per dozen, post free.

The Hammond Waterworks, U.S.A.

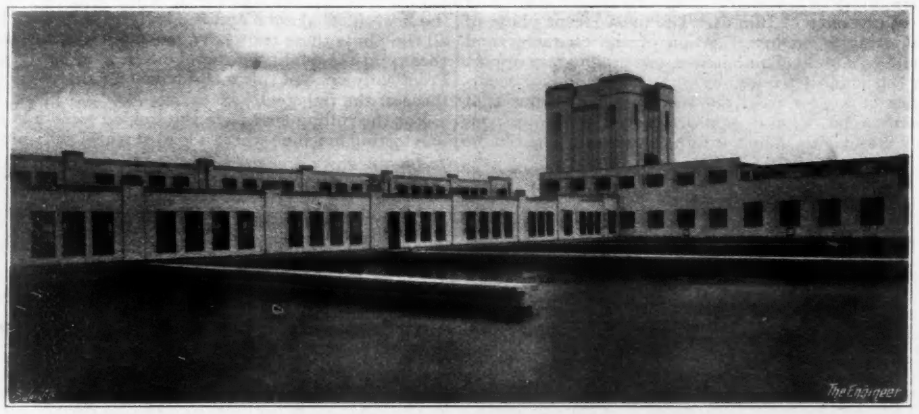
RECONSTRUCTION and modernisation of the waterworks and water distribution system of the City of Hammond (Indiana) have been carried out through the financial co-operation of the Federal Emergency Administration of Public Works. The work done has permitted not only an improved supply to Hammond itself, but also the service of water to the adjoining communities of Munster (Indiana) and Lansing and Calumet City (Illinois).

The work involved may be divided into several parts: (1) Reconstruction of the water purification plant, and its extension to a capacity of 20 million gallons per day; (2) construction of a storage reservoir in the centre of the consumption area to help maintain suitable service pressures; (3) laying of new water mains and construction of loops to avoid existing dead ends in the distribution system. In addition, a meter repair shop and maintenance office is under construction, while the metering vaults and connections to the neighbouring communities served have already been completed.

The purification plant is built, as has been mentioned, for 20 million gallons per day capacity. It stands on filled ground on the shore of Lake Michigan, and takes its water from the lake. The substructure of the plant is reinforced concrete throughout, while the superstructure is light brick masonry. This arrangement fits in well with an old high-lift pump building on the site, which has been retained.

The low-lift pumps of the plant take their feed from a large existing shore well which has been converted into a primary settling well. Three existing cast iron intakes laid in the bed of Lake Michigan feed the well. The main intake is a 42in. diameter cast iron pipe which extends from the shore to an intake crib situated about 1 mile out from shore. The two other intake pipes are 30in. and 24in. respectively, and run out to cribs only ½ mile from shore. They are used for emergency purposes solely, since the water obtained from the other longer intake is of much better quality.

The low-lift pumps are three in number, rated 6950 gallons per minute, 12,500 gallons per minute, and 15,000 gallons per minute, respectively. Any one or even any two of these pumps can be stopped without stopping the plant. They serve to draw water from the primary settling well and deliver it to the reaction basins.



SEDIMENTATION BASINS

The latter are constructed in concrete as two groups of four small basins each. Here the water is mixed with the chemicals necessary for its purification, during thirty minutes, by vertical mechanical stirrers. Feed to and from the basins is so arranged that either of the groups can be taken out of service for repairs without interfering with the water supply.

Chemicals used for the purification are chlorinated ferrous sulphate, lime, and activated carbon. The two former react to form a heavy gelatinous precipitate which carries suspended particles down with it in the sedimentation basins. Activated carbon serves to remove odours and tastes from the water while chlorine serves as a sterilising medium.

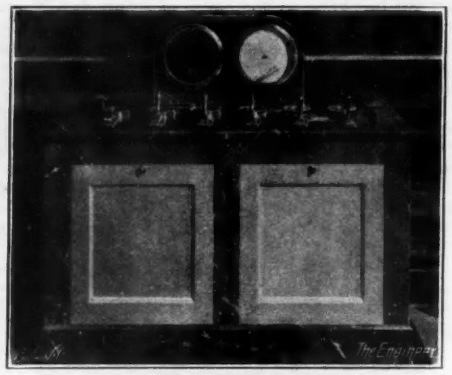
Four dry feed units are provided for handling the chemicals. One of them serves for the ferrous sulphate, one for the lime, and two for carbon. Each unit comprises a large solution tank is which the chemical is thoroughly mixed with water by automatic agitation, water jets, and passage over baffles before being added to the raw water to be treated. Chlorine is provided from three machines, each with a capacity of 300 lb. of chlorine per day. The chlorine in the liquid state is fed to the raw water from 1 ton containers in which it is brought to the plant. Two ammonia feed machines are also provided, the liquefied ammonia being fed to the water from 150 lb. cylinders. Capacity of the ammonia feed apparatus is 100 lb. per day per machine.

Once it has been mixed with the necessary chemicals in the reaction basins, it flows into two sedimentation basins. Here the greater part of the impurities in the water are removed. It then passes through eight sand filters of the mechanical gravity type where the rest of the impurities are removed.

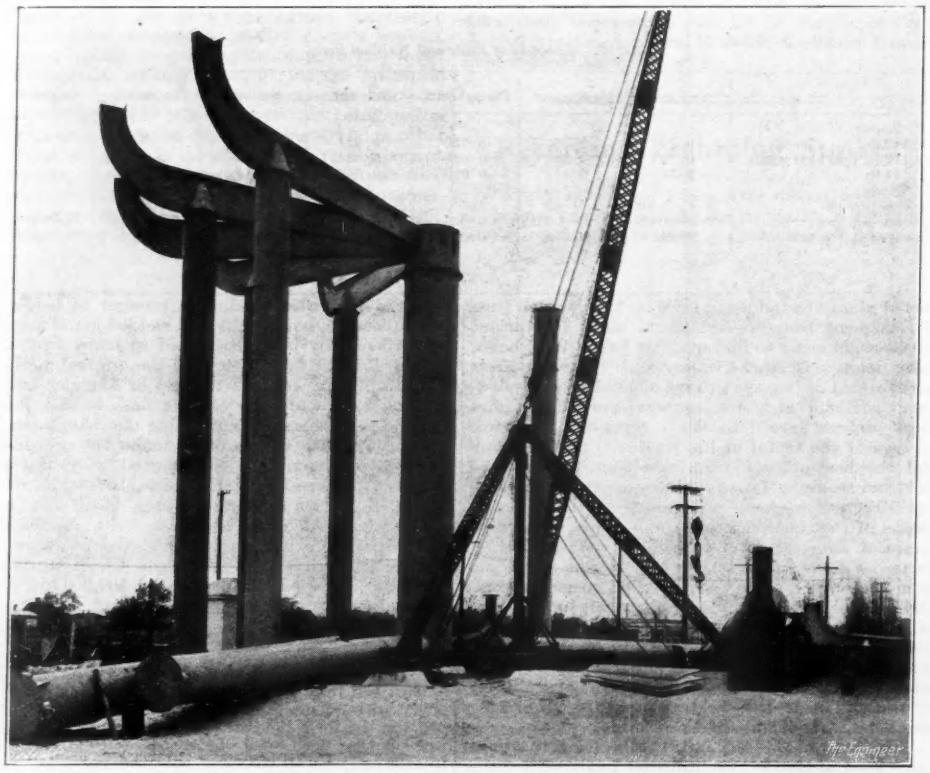
The filter effluent runs to the purified water storage reservoirs, and thence to the existing pumps which deliver it to the mains. Either of the sedimentation basins can be cut out of service for cleaning purposes. They can, moreover, be connected either in series or in parallel with double sedimentation.

The filters are provided with 4in. cast iron under drains, spaced 12in. between centres and discharging into a 36in. concrete manifold provided on the under side of the filter box slab in the filtered water reservoir. The filtering material comprises 18in. of gravel and 30in. of sand. The filters are provided with six wash water troughs, calculated for a capacity equal to a wash water rise of 42in. Each filter is provided with a control desk on which the levers of the five filter valves are grouped. Also mounted on the desk are a loss of head gauge and a rate of flow gauge, each with an inscribing mechanism connected, which provides a graph of these items. A pipe gallery alongside the filters provides space for the valves and rate controllers necessary.

The filtered water reservoir has a capacity of 5 million gallons. It is in reinforced concrete con-



FILTER OPERATING DESK



ERECTION OF STORAGE TANK RISER PIPE, COLUMNS AND GIRDERS

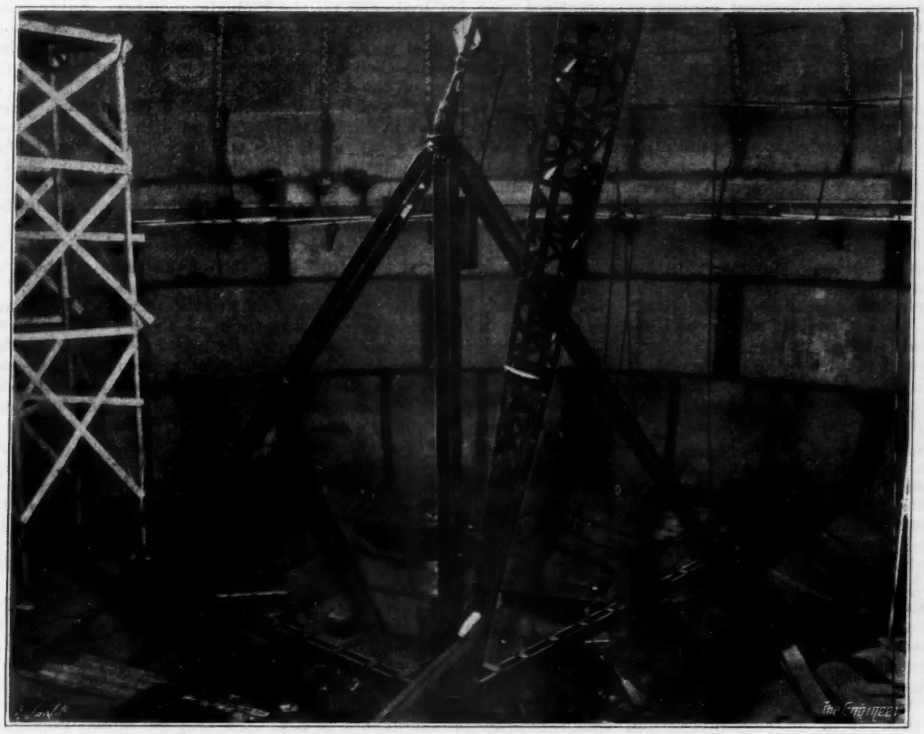
struction, entirely roofed over, and partly underlying the filters for which it forms a foundation. The rest of the reservoir is covered over with a 3ft. 6in. layer of earth, soil taken from the excavations on the job being used for the purpose. A 42in. steel pipe connects the reservoir with the high-lift pump house, which has not been changed, but simply retained from the old plant.

In connection with the construction of the plant, a certain amount of shore protection work was also carried out along the grounds it occupies. This work involved the driving of a line of sheet steel interlocking arch piles, about 760ft. long. It begins at the west face of an existing pier, at about 214ft. from the shore, and runs parallel with the shore for 571ft. before turning shoreward with a curve of 80ft. radius. Tee piles are spaced 40ft. between centres in the structure to permit the addition of future jetties without difficulty, should it prove desirable. The piles were then covered by an embankment of granulated blast-furnace slag, and about 70,000 cubic yards of embankment filled in behind it.

Construction of the elevated storage reservoir in the town was decided upon as the result of careful calculation. The problem to be solved was to eliminate the variations in water pressure which occurred between periods of peak load and times of slack load. Two possible solutions presented themselves, one being the construction of the tank, and the other the complete reconstruction and enlargement of the high-lift pumping plant at the waterworks. Since the existing pumps already have a capacity of 45 million gallons per day if run at full capacity, further extension seemed unnecessary and the tank was decided upon instead. Further arguments in favour of the tank were that it would equalise pressures in the distribution system and the rate of pumping to meet peak demand, and would also reduce operating costs and wear on the pumps, as well as supply a reserve of water for eventual fire demands.

Situated approximately in the centre of the distribution system and on the highest ground in the city, the tank has an operating range in head of 35ft., with a capacity of 1½ million gallons. It is supported on twelve 52in. diameter tubular steel columns and an 8ft. diameter riser pipe, made up of ⅞in. steel plates. Columns and riser were painted inside and out, and all the columns were caulked air-tight

and tested with compressed air to ensure tightness and prevent possible internal corrosion. The tank itself was built in steel plates varying in thickness from $\frac{7}{8}$in. to $\frac{1}{2}$in., the whole riveted together. Foundations of the tank are in concrete and the designed soil pressures are 4000 lb. per square foot. Tank equipment includes access ladders and manholes to provide ready access. A small valve vault is provided to house the altitude valve which automatically regulates the flow of water into and out of the tank, according to the variations in pressure on the distribution system. The tank is also provided with a water level recorder, which transmits its readings to the waterworks automatically. Here they are charted.



ERECTION OF STORAGE TANK PLATES

The reconstruction of the water system has involved the laying of about 20,000ft. of additional water mains, which is about half the programme. These new mains are intended in the first place to strengthen mains which are of insufficient size, and in the second to remove all dead ends in the main system by joining them together in pairs to provide a loop. This method gives double feed with consequent improved pressure. In the engravings reproduced herewith and on page 184 are shown various parts of the waterworks during erection and after completion.

The supervision of all the design work, as well as that of the execution of this whole project, has been in the hands of Mr. Leo Besozzi, Supervising Engineer of the Department of Waterworks.

The Corrosion of Metals*

By OLIVER P. WATTS†

(Continued from page 168)

CORROSION OF TYPE IV: CORROSION BY OXYGEN DEPOLARISATION

ALTHOUGH corrosion of the other three types is far more rapid than type IV, the latter is probably responsible for the major part of the destruction by corrosion of articles made of metals. Because of the rapid attack by corrosion of types I, II, and III, exposure of metals under conditions which permit these types is necessarily of short duration. Since contact with moisture and oxygen are sufficient to incite corrosion of type IV, its occurrence is practically universal, except as these corrosive agents are excluded from continued contact with metals by paint, enamel, &c., or by the formation of a protective film of corrosion product over the surface of the metal. The rusting of iron and steel is an example of this type of corrosion.

Sulphation of the Negative Plates of the Lead Storage Battery.—In the majority of cases of any considerable corrosion of a metal, the product is soluble in the electrolyte. During the discharge of a lead storage battery the lead of the negative plates is progressively converted into insoluble lead sulphate. When a charged lead battery is allowed to stand idle for a long period there is a slow loss of charge, accompanied by the formation of a corresponding amount of lead sulphate in the negative plates. Since lead is incapable of displacing hydrogen gas from sulphuric acid, this action must be a case of corrosion by oxygen depolarisation.

To test this, a half-dozen pieces of bright lead foil, all of the same size, were sealed in air-free, dilute sulphuric acid, and an equal number of pieces were placed in the acid open to the air. The former remained bright, but the latter lost their metallic appearance and gained weight, due to the formation of lead sulphate on their surfaces. At the end of thirty days in air-free electrolyte three specimens lost 3 m.g. each, and in 114 days one specimen had lost 5 m.g. in weight. In the presence of air the gains in weight due to formation of lead sulphate by corrosion were 27 m.g. and 29 m.g. in 30 days, and 31 m.g. in 114 days.

It is evident that the sulphation of the negative plates of lead storage batteries which takes place when they are allowed to stand idle for months, is a case of corrosion of lead by oxygen depolarisation. If it were possible to remove dissolved oxygen from the electrolyte, and keep it out, there would be no "loss of charge" of the negative plates in years of standing idle.

Another Case of Corrosion by Formation of an Insoluble Product.—In a solution of hydrochloric acid or of sodium chloride silver acquires a coating of silver chloride. Four sheets of silver were submerged in a solution of 35 grammes of sodium chloride and 40 c.c. of concentrated hydrochloric acid per litre, and left open to the air. Similar specimens were placed in separate tubes in the same electrolyte, the dissolved air removed as well as may be accomplished by application of a vacuum, and sealed by asphalt, while air was excluded by passage of carbon dioxide into the top of the tube.

In air-free electrolyte the gains in weight were 0·7 m.g. and 0·9 m.g. for metal surfaces of 23·5 and 14·3 square centimetres in 95 days. In the electrolyte open to the air gains in weight were 28·5 m.g. and 24·3 m.g. for metal surfaces of 16·7 and 15·6 square centimetres in 97 days. In air-free solution the silver retained its original brilliance and metallic appearance, but this was completely lost in the solution open to the air. As with lead in sulphuric acid, this formation of a coating of insoluble compound over the metal surface must be a case of corrosion by oxygen depolarisation.

Galvanic Action in Corrosion.—The combination of two different metals in contact in an electrolyte, called a voltaic or galvanic couple, is supposed by many authorities to be responsible for all corrosion of metals. The most striking example of galvanic action that has come to the author's attention is the case of the three-masted schooner yacht "Sea Call." Built with the expectation that she would be the most durable vessel ever constructed, she was scrapped because of corrosion without making a single voyage.

It was planned to construct the entire hull of Monel, but for reasons which need not be given here, the stem, keel, and rudder frame were made of steel. After launching, the hull lay afloat in salt water while the masts, rigging, and interior finish were being installed. After two months afloat it was observed that grass and other marine growths were gathering below the water line, and the vessel was hauled into dry dock to clean the bottom. It was then discovered that severe corrosion of the steel was taking place all along the line of contact with the Monel plates. To remove the steel would have required dismemberment of the hull, so the vessel was broken up and sold as scrap metal. The cost of this experiment in corrosion was reported to the writer to be 500,000 dollars. This is undoubtedly the most expensive example for all time of the damage which may result from placing two different metals in contact in an electrolyte which does not attack either seriously when the metals are not in contact.

Corrosion of the steel was exceptionally damaging in this case because the large total area of steel plus Monel, on which hydrogen was deposited, offered a tremendous surface for depolarisation by oxygen dissolved in the water, and the corrosion equivalent to this depolarisation was all concentrated on the relatively small surface of the steel. Corrosion of the steel was highly localised along the line of contact between steel and Monel, so that penetration of the steel was enormously more rapid than if corrosion had been distributed over the total metal surface immersed.

Metals in Equilibrium with Hydrogen.—Studies in the corrosion of metals in aqueous solutions of acids, bases, and salts leads to the conclusion that, when no visible liberation of hydrogen occurs, metals are in practical equilibrium with displaced hydrogen. When immersed, the metal begins to dissolve with displacement of its equivalent in hydrogen. This process continues until the concentration of hydrogen is such that there remains no point on the metal surface at which the solution pressure of the metal is capable of displacing another atom of hydrogen. The metal is then polarised, to use the common term, and no further dissolving of metal and deposition of hydrogen can take place until some of the polarising hydrogen is removed. Oxygen dissolved in the electrolyte from the air combines with the polarising hydrogen, and the metal corrodes just fast enough to replace the hydrogen thus removed. This process is termed "corrosion by oxygen depolarisation."

In its support the following phenomena are cited: (*a*) The corrosion of metals by oxygen depolarisation; (*b*) the effect of addition of oxidising agents on the corrosion of copper, silver, and several other metals by sulphuric acid, and the corrosion of iron and zinc in solutions of sodium and potassium salts; (*c*) that iron corrodes in a solution of zinc sulphate without displacement of zinc; and (*d*) the gradual change in potential of a platinum cathode in dilute sulphuric acid without visible hydrogen, as the E.M.F. between it and a platinum anode is increased by small steps; and (*e*) the phenomenon of "residual current."

Faraday's law must apply to both residual current and the momentary "polarising current." The corrosion of zinc, iron, copper, &c., in solutions of non-oxidising sodium salts is determined by the presence of atmospheric oxygen in the electrolyte. If this is removed and kept out corrosion does not occur. The same is true of copper and silver in dilute sulphuric acid. To account for this type of corrosion there would seem to be two alternatives—either hydrogen is initially present on the metal surface and oxygen merely removes some of it, or none of the metals which corrode by oxygen depolarisation is capable of displacing even a single atom of hydrogen except oxygen be present. The phenomena of (*c*) and (*d*) above cause the writer to choose the first alternative (*a*) as agreeing better with the known facts of electrolysis and corrosion.

Embrittlement of Steel Springs by Hydrogen.—If there is an invisible film of hydrogen displaced on steel when this is immersed in solutions of sodium salts, it would seem that this might be expected to cause brittleness of steel springs, as does the visible hydrogen evolved on them by corrosion in acids.

Pieces of watch spring were sealed in air-free sea water for 303 days, but no brittleness was apparent on bending the springs. To maintain a higher concentration of hydrogen on the steel several pieces were plated with cadmium on one end, so that the concentration of hydrogen on the steel was considerably greater than that produced by the steel alone. After 107 days in air-free sea water no brittleness could be detected on bending the springs.

Removal of the Polarising Hydrogen by a Vacuum.—Corrosion by oxygen depolarisation is supposed to be due to a slow removal of a polarising film of hydrogen from the metal surface by its combination with oxygen dissolved in the electrolyte from the air. Its removal by any other means should cause the metal to corrode, provided the method of removal does not cause a protective film to form on the metal.

A sheet of copper having a surface area of 40 square centimetres was immersed in half-normal sulphuric acid for thirty-one days, under the vacuum of the laboratory filter pump. The loss by corrosion was 7·9 m.g., instead of about 165 m.g. when the electrolyte was left open to the air. Iron of the same size submerged in deaerated sea water under vacuum for twenty-one days lost only 1·4 m.g. These losses are about 3 per cent. of corrosion in the same electrolytes when open to the air, and do not indicate any effective removal of hydrogen from the metal surface by a vacuum.

That a vacuum did not greatly stimulate corrosion is not proof of the non-existence of the alleged hydrogen film. The very low solubility of hydrogen

* *Bulletin of the University of Wisconsin.*

† Associate Professor Emeritus in Chemical Engineering.

in water may be responsible for so slight a stimulation of corrosion by a vacuum.

Hydrogen Evolution by Iron in Sodium Chloride Solutions.—Bengough states[1] that iron and steel "fully immersed in sea water beneath air may owe from 10 to 60 per cent. of its corrosion to this mechanism," *i.e.*, to evolution of hydrogen gas. In experiments by the writer[2] iron alone and also coupled with brass, copper and Monel, were sealed in air-free normal solutions of sodium and ammonium chlorides for periods of 100 to 250 days without visible evidence of corrosion; hence, in these cases hydrogen was not displaced.

In another experiment a special gas apparatus was used, consisting of two vertical glass tubes connected near their bottoms by a cross tube. A strip of iron was hung in one tube opposite the cross tube, and the apparatus filled with air-free half-normal sodium chloride solution. The apparatus was inclined so that air bubbles, which were continuously passed up the other tube, could not enter the cross tube, but by diffusion would supply air to the whole electrolyte. The iron rusted, but no gas collected in 177 days.

In four separate test tubes pieces of Armco iron were sealed in half-normal sodium chloride solution, air-free. No gas collected in 115 days. It would seem that the hydrogen found by Bengough in the corrosion of iron in sodium chloride solution containing oxygen must have come from some other reaction than the direct displacement of hydrogen gas by the iron.

Protection by Galvanic Action.—Not only may contact between two different metals in electrolytes increase the rate of corrosion of one member of the galvanic couple thus formed, but such contact frequently lessens corrosion of the other member, if this was corroding before contact was made. A square inch of sheet copper in half-normal sodium sulphate open to the air lost 11·8 m.g. in seven days. A similar sheet of copper coupled with an equal sheet of iron lost only 0·9 m.g.

The corrosion of a couple of two different metals in contact, or of a metal containing impurities more noble than itself, appears to take place as follows:—When two different metals, for example, copper and silver, are immersed separately in an electrolyte in which they can corrode only by oxygen depolarisation, each begins to dissolve and displace hydrogen on itself in amounts chemically equivalent to the metal which dissolves. With every atom of hydrogen thus displaced opposition to further deposition of hydrogen increases, and quickly attains equilibrium with the solution pressure of the metal. The metal is now polarised, to use the common term, and corrosion cannot continue until some of the polarising hydrogen is removed.

Since the potentials of the metals are different, the concentration of hydrogen in them must also be different. As soon as contact between the metals is made the metal of greater solution pressure (higher potential) begins to dissolve again by displacing hydrogen on the other. This corrosion continues until the concentration of hydrogen on the cathodic member of the couple becomes great enough to prevent further deposition, *i.e.*, until hydrogen on the cathodic metal is in equilibrium with the higher solution pressure of the anodic or less noble metal. The action resulting from contact between the metals is not a transfer of hydrogen from the anodic to the cathodic metal, but the deposition on the cathodic member of the couple of new hydrogen.

From now on, hydrogen is being removed from the surfaces of both metals by oxygen depolarisation, but weight losses show that corrosion of metal takes place only at the less noble of the two, which is said to protect the other by galvanic action. Since it is admitted by everyone that hydrogen is being removed from the cathodic metal, it may well be asked why this lost hydrogen is not replaced by dissolving of the cathode itself, instead of by corrosion of the more remote anodic metal? The explanation is simple, when it is remembered that the concentration of hydrogen on the cathode is in equilibrium, not with its own solution pressure, but with the higher solution pressure of the anodic metal. Removal of hydrogen from the cathodic metal by a process so slow as that of oxygen depolarisation in ordinary, still electrolytes allows plenty of time for its replacement by corrosion of the anodic member of the couple, before the hydrogen concentration falls to the level of the solution pressure of the cathode. Consequently, the cathode cannot corrode so long as contact is maintained with the anodic metal and this is free to corrode, *i.e.* no protective film forms over it.

Corrosion by oxygen depolarisation, for those metals subject to it, usually goes on continuously in solutions open to the air. It is prevented only by exclusion of oxygen or by formation of a protective film of corrosion product over the surface of the metal. An illustration of corrosion by oxygen depolarisation and its suppression by film formation is the case of two 25-gallon cast iron tanks installed in the electro-plating laboratory of the University over forty years ago. One tank has been used for a solution of soda ash, the other for water for rinsing plated articles. Both were heated by steam coils when in use. The latter rusted through and was discarded thirty years ago, but the former is still in use, with every prospect of giving another forty years of service. Its survival is due to the protective film which forms on iron in alkaline solutions and prevents corrosion, even by oxygen depolarisation.

Hydrogen Deposited on Both Anodic and Cathodic Members of Couples.—There appears to be a widespread belief that in the corrosion of couples of two different metals in contact, or of a single metal containing impurities more noble than itself, the hydrogen displaced by corrosion of the metal is deposited only on the more noble or cathodic member of the couple.

"Dissimilar materials in contact have the effect that would be expected from the electro-chemical nature of corrosion. When two such materials, in electrical contact, are submerged in a corroding solution, the electrical contact is completed, permitting the one to become anodic and enter solution, while the other becomes cathodic and is plated with hydrogen. This may be caused by discontinuities in surface films, mill scale, or metallic coatings that are cathodic to the base metal and thus give rise to pitting."[3]

"If the metal is not uniform, varying from place to place in chemical or physical character, it is certain that at the moment of immersion there cannot be equilibrium. The potential will vary from point to point, and a current must be set up between the different points. At certain places (the anodic areas) the metal will commence to pass into the ionic condition; at other places the cathodic areas, hydrogen ions will be discharged."[4]

"It is desirable to remove dissolved air from the acid, because by the aid of absorbed oxygen every metal, as far as is known, is dissolved to some extent without development of hydrogen gas. This, of course, is to be explained by the supposition that hydrogen deposited at the local cathodes is oxydised by the oxygen which thus acts as a depolariser."[5]

"The mechanism (of corrosion in salt solutions) can best be described by imaginging the corrosion of a bar of iron containing fragments of copper, immersed in a solution of sodium chloride, which contains oxygen. The copper or other relatively noble metallic inclusions act as cathodes and the adjacent areas of iron act as anodes. At the anodic areas chlorine ions are discharged and react with the iron to form ferrous chloride. At the cathodic areas sodium hydroxide and hydrogen are formed, the hydrogen being removed by oxidation through dissolved oxygen."[6]

When two different metals are connected and immersed in an electrolyte from which hydrogen is evolved on only one of them, whether hydrogen appears on the anodic (less noble) or on the cathodic metal, depends on which has the lower discharge potential of hydrogen, and not on which of the pair is the cathode of the galvanic cell constituted by the two metals and electrolyte. The same condition holds when two metals in contact are made cathode in an electrolyte from which there is no evolution of hydrogen on merely immersing the couple. When the E.M.F. between the pair as cathode and a platinum anode is slowly raised, current flows to both members of the cathode and hydrogen is deposited on each metal, although for a time no hydrogen is visible on either. Hydrogen is first seen on the metal on which the discharge potential of hydrogen is the lower, regardless of whether this metal was initially the anode or cathode of the pair.

Depolarisation at Cast Iron versus Armco Iron.—The grey cast iron used contained 3·46 per cent. carbon and 2·38 per cent. silicon, against a reputed 0·15 per cent. total impurities in the Armco iron. If hydrogen is deposited only on noble impurities in metals, cast iron should be about forty-five times more effective in promoting corrosion by oxygen depolarisation than is Armco iron.

An amalgamated zinc gauze, 3 cm. by 4 cm., was placed between electrodes 2·5 cm. square, of cast iron and Armco, with glass rod separators giving a spacing of 1·4 mm. The edges of the relatively thick cast iron were covered with wax to expose equal surfaces of the two metals. Three minutes after closing the switch the currents were 1·1 milliampere to each member of the cathode, and at the end of an hour 0·24 and 0·26 milliampere to the cast iron and Armco, respectively. It is not credible that these currents should result from deposition of hydrogen on, and depolarisation at the impurities only in each metal of the dual cathode.

Current Distribution to a Compound Cathode.—To simulate a metal containing cathodic impurities, compound cathodes consisting of two different metals were set up, with an anode of a more active metal equally spaced between them, and the currents to the two portions of the cathode were read by separate instruments. Since no hydrogen was evolved as gas, the current measured the rates of deposition of hydrogen and its removal by depolarisation at each member of the compound cathode.

With sheets of silver and copper 2·5 cm. square, spaced 6 mm. on each side of an equal sheet of Armco iron in 750 cubic centimetres of a half normal solution of sodium sulphate, the current dropped from 4·4 and 6·4 milliamperes to the copper and silver at the end of two hours, to 0·12 and 0·18 milliamperes after six hours. The air-liquid interface was 33 square centimetres. Repeated, the currents were 0·23 and 0·21 milliamperes after twenty-one hours. Although copper is anodic to silver in sodium sulphate, hydrogen was deposited on its surface in amounts which equalled that deposited on the more noble silver with which it was in contact.

Calculation of Depolarisation at the Anodic Member of Couples.—In the corrosion of couples of two different metals by displacement of hydrogen, it is possible, by placing a micro silver-coulombmeter in series with the cell, to learn how much of the corrosion of the anodic member was due to deposition of hydrogen on the cathodic member. Subtraction of this from the total corrosion gives the weight of metal which dissolves by depositing hydrogen elsewhere than on the cathodic member of the couple, *i.e.*, on the anodic member.

For nickel and platinum 2·5 cm. square, 1 cm. apart in normal sulphuric acid with 33 square centimetres of air-liquid surface, it was found that depolarisation at the nickel accounted for 73, 67, 72, and 75 per cent. of the total corrosion in four different experiments. For copper-platinum couples similar results were obtained. In seven experiments the per cent. of depolarisation which occurred at the anode varied from 75 to 84 per cent. of the total corrosion.

With two copper electrodes, increase of the air-electrolyte interface from 33 to 284 square centimetres increased corrosion by 47 per cent., but this change for the copper-platinum couple increased corrosion only 22 per cent. Two copper electrodes lost materially more than did the copper-platinum couple at a spacing of 1 cm.

In separate experiments at a spacing of 1 cm. in sea water for five days, the couples iron-copper and iron-amalgamated silver lost 0·0262 and 0·0275 grammes respectively. Depolarisation at the anodic metal was responsible for 42 and 36 per cent. of the total corrosion. It is noteworthy that deposition of hydrogen on and depolarisation at the amalgamated silver cathode was responsible for 64 per cent. of the corrosion of the copper of that couple. The uniformity of surface supposed to be presented by the amalgamated metal has not prevented deposition of hydrogen on it!

The belief, commonly held, that hydrogen displaced on the anodic member of the couples in these experiments is deposited only on noble impurities in the metal would require a miracle in the diffusion of oxygen through the solution. If hydrogen were deposited only on impurities in the anodic metal instead of on its entire surface, these hydrogen-laden impurities would have to be endowed with a power of attracting oxygen to themselves hundreds of times faster than it diffuses to equal hydrogen-laden areas of the platinum or other cathodic member of the couple, which is, of course, impossible. Deposition of hydrogen and depolarisation by oxygen must have taken place at the anodic metal itself, in addition to occurring at any impurities which it may contain.

Effect of Stirring at Anode versus Cathode.—If, in corrosion of type IV of two metals in contact, hydrogen were displaced only on the cathodic or more noble member of the couple, stirring of the electrolyte at the cathode should result in a great increase in corrosion, while stirring at the anodic member should have little or no effect.

Two-compartment cells were made by cementing vertical parchment diaphragms into several tumblers, and copper-platinum couples were inserted, with the metals on opposite sides of the diaphragm in half-normal sulphuric acid. In three of the cells a jet of air was bubbled across one electrode for four days.

Taking corrosion of the copper of a copper-platinum couple in the still solution as 100 per cent., stirring by an air jet at the cathodic platinum, where it is generally supposed that all hydrogen displaced by the corrosion of copper is deposited, increased corrosion 72 per cent. Similar stirring at the anodic copper increased corrosion 909 per cent. as an average of two trials. In the face of this evidence, the belief that all hydrogen displaced by the corrosion of copper is deposited on the platinum, and on such traces of cathodic impurities as may have been present in the copper, appears to the author utterly untenable.

(To be continued)

THE LATE MR. S. D. WHITE.—We regret to have to announce the death on August 6th, at the age of sixty-five, of Mr. S. D. White, a director of the General Electric Company, Ltd. Mr. White began his career with the company in 1888, and last year he was the recipient of a silver salver presented by Lord Hirst and his colleagues on the board to mark the completion of fifty years' service with it. Soon after the company moved from its original headquarters in Great St. Thomas Apostle to Queen Victoria Street, Mr. White was transferred to the staff of the counting house, and in 1894 became manager of the bell department. Later he became manager of the Government and railways department, and among the other departments in which he had a controlling interest were the bell, telephone, and radio departments. He was elected a director in 1915.

[1] *Chemistry and Industry*, page 11, 197, 1933.

[2] "Trans.," Electrochem. S., V. 67, page 240, 1935.

[3] "Corrosion," by F. N. Speller, page 189, 1935.

[4] U. R. Evans, *J.*, Inst. Met., 30, 244, 1923.

[5] W. Palmer, "The Corrosion of Metals," page 178, Part I, 1929.

[6] E. S. Hedges, "Protective Films on Metals," page 44, 1923.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

Iron and Steel Exports

The exports of iron and steel and manufactures thereof in July, according to the Board of Trade Returns, rose to 177,226 tons, valued at £3,490,438, compared with 162,289 tons, valued at £3,238,642 in June. The following are details of the principal exports :—

	1938. Total. Tons.	1939. June. Tons.	1939. July. Tons.
Pig iron : Total	94,012	6,283	5,872
Forge and foundry	44,375	4,156	4,057
Acid	25,690	1,906	1,779
Basic	23,947	221	36
Ferro-alloys	6,787	391	245
Sheet bars, bright steel bars, and wire rods	22,162	1,452	1,056
Bars and rods, other kinds	102,074	6,796	6,135
Angles, shapes, and sections	67,319	5,995	7,110
Girders, beams, joists, &c.	33,525	2,435	3,202
Hoop and strip	37,408	3,311	2,566
Plates and sheets, ⅛in. and over : Total	131,052	17,006	20,084
South Africa	7,551	2,373	1,270
British India	16,926	1,596	801
Australia	7,551	372	379
Canada	1,966	819	863
Other British countries	30,085	2,620	1,955
Denmark	38,611	2,856	7,633
Holland	10,633	3,776	4,791
Plates and sheets under ⅛in.: Total	63,516	9,134	5,960
British India	4,550	300	255
Australia	16,398	308	240
Canada	5,097	854	609
Mexico	1,880	—	—
Argentine Republic	13,113	4,965	2,408
Galvanised sheets	147,332	13,785	11,897
Tinned plates	319,403	28,862	34,985
Tubes, pipes, and fittings : Cast :			
Up to 6in. diameter	48,985	5,155	5,844
Over 6in. diameter	42,946	5,646	4,675
Wrought	220,011	17,214	18,659
Railway material :			
Steel rails, new	105,999	7,177	10,360
Sleepers, fish-plates, and sole-plates	25,618	1,330	1,263
Total all iron and steel	1,917,639	162,289	177,266

Iron and Steel Imports

The following figures, taken from the Board of Trade Returns for July, show that imports of iron and steel and manufactures thereof increased to 220,646 tons from 199,933 tons in the previous month, and the value to £1,910,683 from £1,821,141. Only the figures for the most important countries are given :—

	1938. Total. Tons.	1939. June. Tons.	1939. July. Tons.
Pig iron : Total	395,151	25,052	29,325
British India	155,653	16,763	22,902
Foreign countries	231,365	8,289	4,419
Ferro-alloys	47,606	6,758	7,782
Blooms, billets, and slabs :			
Total	314,989	37,753	43,689
British countries	59,462	12,494	15,087
Sweden	1,104	87	36
Germany	27,569	1,781	1,876
Belgium	55,417	5,483	10,482
France	101,188	15,949	15,541
Other foreign countries	70,249	1,959	667
Sheet bars	33,606	53,788	79,449
Wire rods	60,021	10,536	6,689
Other bars and rods	102,919	13,285	12,212
Angles, shapes, and sections	44,958	5,495	6,564
Girders, beams joists, &c.:			
Total	60,134	8,486	4,435
Belgium	5,493	1,772	665
France	38,191	3,974	638
Other foreign countries	14,534	2,740	3,132
Plates and sheets (not coated)	68,009	16,232	11,986
Wrought tubes	22,880	2,508	2,502
Railway material	20,458	1,307	739
Bolts, nuts, and metal screws	7,109	518	1,030
Total from countries :			
British India	155,664	16,763	22,902
Canada	117,051	21,271	22,633
Germany	94,685	9,926	9,673
Sweden	89,804	12,985	8,629
Holland	32,583	433	431
Belgium	273,586	59,380	53,746
Luxemburg	58,570	16,090	18,169
France	257,304	50,457	49,037
Czechoslovakia	12,367	286	610
United States	20,671	6,399	4,703
Total imports, iron and steel	1,340,735	199,933	220,646

The Pig Iron Market

It is very unusual for any development of importance to take place in the pig iron market during August, but this year there is undoubtedly more business moving than is customary and there is some stirring in the foundry iron market which has been comatose for a long time. On the North-East Coast most of the consuming industries have been closed down this week, but production at the blast-furnaces and coke ovens has not been interrupted. Of the thirty furnaces operating in this district only one is engaged on the partial production of foundry iron, and in a number of cases users are satisfying their requirements with Midland brands. The remainder of the furnaces in operation are engaged upon steel making iron, of which there seems to be some stringency. Lately there has been fresh talk of a possible reduction in the price of Cleveland, which is not fixed for any definite period.; but the makers seem indifferent to the small trade they are doing in this quality or to the imports from other districts, and are concentrating their energies on the output of basic and hematite. The demand for Midland foundry iron has improved somewhat of late, as a few consumers have purchased with a view to increasing their stocks in hand. The demand, however, is poor and an improvement in this department rests very largely upon an expansion of activity in the light castings industry. The production of low phosphorus grades, however, is on a good scale, and the demand is widely spread over a large number of engineering concerns, the majority of which are engaged upon Government work. In this department many consumers have bought well forward and are not likely to be in the market for the next month or two. In the Scottish market, also, the demand for foundry iron has improved to some degree, but whilst the light castings makers formerly used to absorb considerable quantities of Cleveland foundry iron they now for the most part use Midland irons, which are obtainable at 1s. 3d. below the Cleveland price. The market for hematite remains fairly active, although the first rush of buying which followed the reduction in prices at the end of June has subsided. There is still a good demand, but although the stocks which had accumulated at the blast-furnaces have been materially reduced, they are still on the heavy side. Merchants complain that export business is impossible at the price of £5 5s. for No. 1 quality, but makers show no disposition to yield on this point, and most overseas business seems to be passing into the hands of the Continental makers.

British Iron and Steel Production

The British Iron and Steel Federation's statement on iron and steel production in July indicates that, allowing for the usual annual stoppages at a number of works, mainly in Scotland, the daily rate of steel output rose by approximately 1000 tons. The output at 1,153,000 tons compares with the June figure of 1,175,600 tons and exceeds by 94,000 tons the previous highest record for July in 1937. The daily production of pig iron also showed an increase during July and amounted to 743,600 tons, compared with 715,700 tons in June. Last month's total included 112,100 tons of hematite, 501,000 tons of basic iron, 103,800 tons of foundry, and 15,700 tons of forge pig iron. This shows a rise of 900 tons in the case of hematite, 24,500 tons of basic, 5200 tons of foundry, and 300 tons of forge iron over the figures for the previous month. Five furnaces restarted operations during July and four went out of commission, making the number in blast at the end of July 115. The following table shows the average monthly production over a period of years and the output for the past seven months :—

	Pig iron. Tons.	Steel. Tons.
1913—Monthly average	855,000	638,600
1920 " "	669,500	755,600
1929 " "	632,400	803,000
1931 " "	314,400	433,500
1932 " "	297,800	438,500
1933 " "	344,700	585,300
1934 " "	497,400	737,500
1935 " "	535,300	821,600
1936 " "	643,500	982,100
1937 " "	707,800	1,082,000
1938 " "	563,600	866,200
1939—January	500,500	811,700
February	516,000	971,100
March	603,600	1,170,900
April	608,900	1,058,200
May	692,100	1,218,100
June	715,700	1,175,600
July	743,600	1,153,100

Current Business

Plans have been passed for a large extension to be erected at the works of the Clyde Alloy Steel Company, Ltd., Motherwell, to provide for a new bar mill and other works accommodation. The total cost of the scheme will be about £100,000. Plans have also been passed for an extension to the engineering workshops of the Steel Construction Company, Ltd., at Whitegates, Motherwell, which it is estimated will cost £1500. A factory is being erected for Wingrove and Rogers, Ltd., manufacturers of electrical equipment, at Domville Road, Liverpool, and Littlewoods, Ltd., will build store premises in Clayton Street, Liverpool, at an estimated cost of £250,000. Pumping by English Lead Mines Exploration, Ltd., London, is proceeding at Ladywash Lead Mine, near Eyam, Derbyshire, which has not been worked for twenty years, and it is hoped that it will be found profitable to resume mining operations. A new iron ore mine in Cumberland is being developed by United Steel Companies, Ltd., to augment supplies to its subsidiary blast-furnaces at the Workington Iron and Steel Company, Ltd., Workington. Stewarts and Lloyds, Ltd., are starting another furnace at the Clydesdale Steel Works, Mossend, to cope with the increased demand for seamless tubes. The Tees-Side Bridge and Engineering Company, Ltd., and Pease and Partners, Ltd., Middlesbrough, are the principal recipients of the Southern Railway Company's order for 12,000 tons of railway chairs, placed with firms on Tees-side. The Bedlington Coal Company, Ltd., has ordered from Colliery Engineering, Ltd., Sheffield, a complete coal-preparation plant capable of treating 220 tons of coal per day. The firm has also received an order from the new Hucknall Colliery Company, Ltd., for a Barvoys washer to deal with 100 tons of coal hourly, and from Lambton, Hetton and Joicey Collieries, Ltd., for a Hoyois trough washer to deal with 55 tons of coal per hour. The Department of Overseas Trade announces that the following contracts are open for tender :—Johannesburg, Union Tender and Supplies Board : Supply of one steam boiler (Johannesburg, September 7th). South African Railways and Harbours : Approximately 9 tons of steelwork, together with bolts, rivets, &c. (Johannesburg, September 7th). Supply and delivery of quantities of extruded free turning quality brass and bronze bars (Johannesburg, September 18th); supply and delivery of approximately twelve tons of steelwork, including bolts, nuts, &c., for a footbridge (Johannesburg, September 21st); quantities of seamless copper pipes in various sizes and gauges for locomotives (Johannesburg, October 9th); quantities of bar steel, round, square, billets or blooms, slabs, hexagon bars, strips, tee bars, angles, special sections, &c. (Johannesburg, August 28th). Durban, Electricity Supply Commission : Supply, delivery, and erection of coal-handling equipment and auxiliary plant for the Congella power station (Johannesburg, September 14th).

Copper and Tin

Expectations that the increase in the production quota would affect prices turned out to be without foundation. No doubt this was partly because Germany came into the market as a buyer. It appears, however, that the quantities purchased were much exaggerated in the daily Press, and at the outside did not amount to between 1000 and 1200 tons. Whilst it is suggested that this active buying is due to the German Government's desire to accumulate war stocks, it must be remembered that for some time the German consumers have bought little copper and that the reserves available for domestic consumption had fallen to low levels. For some time past sellers have demanded confirmed bankers' credits on sales to German consumers, and this practice is followed in the present buying movement. Another reason why this market has continued firm is that the statistics for July showed a favourable position, as the refined stocks were reduced by about 23,000 short tons to 490,491 tons. The figures disclosed that the United States production dropped in July to 57,339 tons from 61,719 tons in June, and in the rest of the world to 100,897 tons from 111,486 tons, the total refined output being 158,236 tons, against 173,205 tons in June. Consumption in the United States was slightly better at 59,681 tons, against 53,573 tons in June, and in the rest of the world fell off from 126,860 tons in June to 121,806 tons in July, the total apparent consumption being 181,487 tons, against 180,433 tons in June. The stocks in the United States at the end of July were 316,543 tons, compared with 335,012 tons on June 30th, whilst in the rest of the world the stocks on July 31st were 173,876 tons, against 178,658 at the end of June, the total refined stocks on July 31st being 490,419 tons, compared with 513,670 tons on June 30th. The standard market, after developing a slightly easier tone upon the announcement of the increase in production, strengthened again as a result of active buying and favourable statistics. . . . Holiday conditions have ruled in the tin market, and although the price of prompt tin is held at the £230 level, trading remains dull. The demand from the United States continues quiet and there is little expectation of an improvement in business from this direction until the early autumn. It is generally thought that consumption in America is good and that eventually consumers there will have to enter the market on a more extensive scale than for some time. The belief that the production quotas will be increased for the fourth quarter of the year persists, as there is a certain stringency in the market.

Lead and Spelter

It is not surprising that after the recent sharp advance in the lead price a reaction should occur, and that prices should show a tendency to recede. The underlying conditions in this market, however, have not changed and no pronounced decline is anticipated. Consumption is on a good scale in this country and has improved somewhat on the Continent. In the United States also the domestic sales have been satisfactory and this small buying movement is expected to continue for a time. The production of lead appears to be well under control and there is no important quantity of surplus metal. In fact, the producers seem to have been fairly successful in adjusting the supply to the demand. There is some scarcity of prompt lead, which is partly due to the diversion of Mexican supplies to the Continent, and the absence of any shipments from Spain since the cessation of hostilities. The foreign demand for lead has been quiet, and as consumers abroad appear to have covered themselves for some time ahead it is likely to remain light. It is suggested that now that the producers have been able to improve the statistical position the present output restrictions may be somewhat relaxed. In this country considerable quantities of lead are passing into consumption as a result of rearmament, and at the same time the commercial demand remains strong. The cable makers continue to absorb good quantities and the lead pipe and sheet makers are maintaining a good output. The figures issued by the American Bureau of Metal Statistics give the world's consumption outside Russia, the United States and Japan, as averaging 89,821 tons monthly over the past three months, compared with a monthly average over the whole of last year of 90,133 tons. The world's production of refined lead in June is given as 150,576 tons, compared with 169,193 tons in May. The production for the first half of 1939 totalled 944,764 tons. . . Prices in the spelter market have fluctuated within narrow limits during the past few days and the market has shown greater firmness. Supplies are adequate to meet requirements, and when prices develop a tendency to advance some nervousness usually makes itself felt that the higher rates may result in an increase in production. On the other hand, consumption continues at a good rate and is likely to be maintained whilst the demand for metal in the production of A.R.P. shelters and for rearmament purposes continues so strong. The present range of values cannot be considered high, but notwithstanding the favourable features just mentioned there is a pronounced lack of confidence in the future of this metal. No doubt if the efforts to establish a spelter Cartel are successful sentiment would change, but at the moment there seems little prospect of anything definite emerging for some time.

Current Prices for Metals and Fuels

Makers' official home trade price, per ton, delivered buyers' stations. *Joists, Sections, Bars and Plates are subject to a rebate of 15s. to home users purchasing only from Associated British Steelmakers. †Export prices are for Empire Markets; for other Markets British quotations conform to Cartel prices.

PIG IRON.

Foundry home prices, except for Scotland, less rebate of 5/-.

	Home.	Export.
(D/d Teesside Area.)	£ s. d.	£ s. d.
N.E. Coast—		
Hematite Mixed Nos.	5 15 0	—
„ No. 1	5 15 6	5 15 0
Cleveland—		
No. 1	5 2 0	5 2 6
No. 3 G.M.B.	4 19 0	5 0 0
No. 4 Foundry	4 18 0	—
Basic	4 12 6	—
Midlands—		
Staffs— *(Delivered to Black Country Station.)*		
North Staffs Foundry	5 1 0	—
„ „ Forge	4 18 0 to £5 0 0	—
Basic	4 12 6	—
Northampton—		
Foundry No. 3	4 18 6	—
Forge	4 15 6 to £4 17 6	—
Derbyshire—		
No. 3 Foundry	5 1 0	—
Forge	4 18 0 to £5 0 0	—
Scotland—		
Hematite, f.o.t. furnaces	5 15 6	—
No. 1 Foundry, ditto	5 3 0	—
No. 3 Foundry, ditto	5 0 6	—
Basic, d/d	4 12 6	—
N.W. Coast— Hematite Mixed Nos.	5 15 6 d/d Glasgow; 6 1 0 „ Sheffield; 6 7 0 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
Lancs and Yorks—	£ s. d.	£ s. d.
Crown Bars	12 5 0	—
Best Bars	12 15 0	—
Midlands—		
Crown Bars	12 5 0	—
Marked Bars (Staffs)	15 15 0	—
No. 3 Quality	10 17 6	—
No. 4 Quality	11 7 6	—
Scotland—		
Crown Bars	12 5 0	12 5 0
Best	12 15 0	12 15 0
N.E. Coast—		
Crown Bars	12 5 0	12 5 0
Best Bars	12 15 0	12 15 0
Double Best Bars	13 5 0	13 5 0
Northern Ireland and Free State—		
Crown Bars, f.o.q.	12 17 6	—

STEEL.

	*Home.	†Export.
London and the South—	£ s. d.	£ s. d.
Angles	10 10 6	10 0 0
Tees	11 10 6	11 0 0
Joists	10 10 6	10 0 0
Channels	10 15 6	10 5 0
Rounds, 3in. and up	11 10 6	11 0 0
„ under 3in.	11 17 6‡	11 0 0
Flats, under 5in.	11 17 6‡	11 0 0
Plates, ¼in. (basis)	10 15 6	10 2 6
„ 5/16in.	11 0 6	10 7 6
„ ⅜in.	11 5 6	10 12 6
„ 7/16in.	11 10 6	10 17 6
Un. 7/16in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	11 12 6
Boiler Plates, ¼in.	11 13 0	11 12 6
North-East Coast—	£ s. d.	£ s. d.
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 15 0‡	11 0 0
Plates, ¼in. (basis)	10 10 6	10 2 6
„ 5/16in.	10 15 6	10 7 6
„ ⅜in.	11 0 6	10 12 6
„ 7/16in.	11 5 6	10 17 6
Un. 7/16in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	11 12 6
Boiler Plates, ¼in.	11 8 0	11 12 6
Midlands, and Leeds and District—	£ s. d.	£ s. d.
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 16 0‡	11 0 0
Flats, 5in. and under	11 15 0‡	11 0 0
Plates, ¼in. (basis)	10 13 0	10 2 6
„ 5/16in.	10 18 0	10 7 6
„ ⅜in.	11 3 0	10 12 6
„ 7/16in.	11 8 0	10 17 6
Un. 7/16in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	11 12 6
Boiler Plates, ¼in.	11 10 6	11 12 6

STEEL (*continued*).

	*Home.	†Export.
Glasgow and District—	£ s. d.	£ s. d.
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 15 0‡	11 0 0
Flats, 5in. and under	11 15 0‡	11 0 0
Plates, ¼in. (basis)	10 10 6	10 2 6
„ 5/16in.	10 15 6	10 7 6
„ ⅜in.	11 0 6	10 12 6
„ 7/16in.	11 5 6	10 17 6
Un. 7/16in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	11 12 6
Boiler Plates, ¼in.	11 8 0	11 12 6
South Wales Area—	£ s. d.	£ s. d.
Angles	10 8 0	10 0 0
Tees	11 8 0	11 0 0
Joists	10 8 0	10 0 0
Channels	10 13 0	10 5 0
Rounds, 3in. and up	11 8 0	11 0 0
„ under 3in.	11 15 0‡	11 0 0
Flats, 5in. and under	11 15 0‡	11 0 0
Plates, ¼in. (basis)	10 13 0	10 2 6
„ 5/16in.	10 18 0	10 7 6
„ ⅜in.	11 3 0	10 12 6
„ 7/16in.	11 8 0	10 17 6
Un. 7/16in. to and incl. 6 lb. per sq. ft. (8-G.)	11 12 6	11 12 6

Ireland—f.o.q.	Belfast.	Rest of Ireland.
	£ s. d.	£ s. d.
Angles	10 13 0	10 15 6
Tees	11 13 0	11 15 6
Joists	10 13 0	10 15 6
Channels	10 18 0	11 0 6
Rounds, 3in. and up	11 13 0	11 15 6
„ under 3in.	12 0 0‡	12 2 6
Plates, ¼in. (basis)	10 15 6	10 18 0
„ 5/16in.	11 0 6	11 3 0
„ ⅜in.	10 5 6	11 8 0
„ 7/16in.	11 12 6	12 10 0
Un. 7/16in. to ¼in. incl.	11 12 6	11 12 6

‡ *Rounds and Flats tested quality; untested, 3s. less.*

OTHER STEEL MATERIALS

Sheets.	Home. £ s. d.	Export, f.o.b. £ s. d.
11-G. and 12-G., d/d	13 15 0	11-G. to 14-G. 11 5 0
13-G., d/d	14 2 6	15-G. to 16-G. 11 15 0
14-G. to 20-G., d/d	14 10 0	17-G. to 18-G. 12 0 0
21-G. to 24-G., d/d	14 15 0	19-G. to 20-G. 12 5 0
25-G. and 26-G., d/d	15 10 0	21-G. to 22-G. 12 17 6

South Africa, Rhodesia, Nyasaland, £14; Canada, £14 12s. 6d., f.o.b. basis. Irish Free State, £14 15s., f.o.q., 4-ton lots.

The above home trade sheet prices are for 4-ton lots and over; 2-ton to 4-ton lots, 7s. 6d. per ton extra; and under 2-ton lots to 10-cwt., £2 per ton extra.

Galvanised Corrugated sheets, basis 24-G.—

Home.	£ s. d.
4-ton lots and up	17 5 0
2-ton to 4-ton lots	17 12 6
Under 2 tons	18 17 6

Export: India, £17 15s. c.i.f.; Irish Free State, £17 5s., f.o.q.; General, £15 15s., f.o.b., 24-G. basis.

Tin-plates—
20 by 14 basis, f.o.t., Bristol Channel Ports, 20s. 4½d.
Tin-plate Bars, d/d Welsh Works, £7 5s.

Billets—100-ton lots and over, 35 to 100 tons, 5s. extra; less than 35 tons, 10s. extra.

	£ s. d.
Soft (up to 0·25% C.), untested	7 7 6
„ „ „ tested	7 12 6
Basic (0·33% to 0·41% C.)	7 17 6
„ Medium (0·42% to 0·60% C.)	8 10 0
„ Hard (0·61% to 0·85% C.)	9 0 0
„ „ (0·88% to 0·99% C.)	9 10 0
„ „ (over 0·99% C.)	10 0 0
Rails, Heavy, 500-ton lots, f.o.t.	9 10 0
„ Light, f.o.t.	8 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	4/5 per lb.	
Ferro-Tungsten	4/4 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 10 0	7/6
„ „ 6 p.c. to 8 p.c.	£23 5 0	7/6
„ „ 8 p.c. to 10 p.c.	£23 5 0	7/6
„ „ Max. 2 p.c. carbon	£36 0 0	11/-
„ „ „ 1 p.c. carbon	£38 5 0	11/-
„ „ „ 0·5 p.c. carbon	£41 0 0	12/-
„ „ „ carbon-free	10d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose), 76 p.c.	£16 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 10 0 scale 5/- p.u.	
„ „ 75 p.c.	£17 0 0 scale 6/- p.u.	
„ Vanadium	14/- per lb.	
„ Molybdenum	4/10 per lb. 5/- forward	
„ Titanium (carbon-free)	9d. per lb.	
Nickel (per ton)	£185 to £190 per ton	
Cobalt	8/6 to 8/9 per lb.	

NON-FERROUS METALS.

(Official Prices, August 16th.)

Copper—		
Cash	£44 6 3 to £44 7 6	
Three Months	£44 7 6 to £44 8 9	
Electrolytic	£50 5 0 to £50 15 0	
Best Selected Ingots, d/d Birmingham	£50 10 0	
Sheets, Hot Rolled	£80 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	13d.	13d.
„ Brazed (basis)	13d.	13d.
Brass—		
Ingots, 70/30, d/d Birmingham	£39 10 0	
	Home.	Export.
Tubes, Solid Drawn 2/1 Alloy	11¼d.	11¼d.
„ Brazed	13¼d.	13¼d.
Tin—		
Cash	£229 17 6 to £230 0 0	
Three Months	£225 5 0 to £225 10 0	
Spelter—		
Cash	£14 8 9 to £14 10 0	
Three Months	£14 12 6 to £14 13 9	
Lead—		
Cash	£15 15 0 to £15 16 3	
Three Months	£15 12 6 to £15 13 9	
Aluminium Ingots (British)	£94 (net)	

FUELS.

SCOTLAND

	Export.
Lanarkshire—	
(f.o.b. Grangemouth)—	
Navigation Unscreened	18/- to 19/-
Hamilton Ell	17/6
Splints	20/-
Ayrshire—	
(f.o.b. Ports)—	
Steam	17/- to 17/6
Fifeshire—	
(f.o.b. Methil or Burntisland)—	
Prime Steam	18/-
Unscreened Navigation	18/6
Lothians—	
(f.o.b. Leith)—	
Hartley Prime	18/-
Secondary Steam	17/6

ENGLAND

South Yorkshire, Doncaster—	
Steam Hards	19/- to 20/-
Washed Smalls	16/- to 17/-
Northumberland, Newcastle—	
Blyth Best	19/- to 19/6
„ Second	18/- to 18/6
„ Best Small	15/6
Unscreened	17/- to 18/-
Durham—	
Best Gas	19/9
Foundry Coke	26/- to 28/-

SOUTH WALES

Cardiff—	
Steam Coals:	
Best Admiralty Large	23/6 to 24/-
Best Seconds	23/- to 23/6
Best Dry Large	23/- to 23/6
Ordinaries	23/-
Bunker Smalls	16/- to 17/6
Cargo Smalls	15/- to 15/6
Dry Nuts	27/6 to 28/-
Foundry Coke	35/- to 42/6
Furnace Coke	30/- to 33/6
Patent Fuel	25/6
Swansea—	
Anthracite Coals:	
Best Large	35/- to 38/-
Machine-made Cobbles	38/6 to 42/6
Nuts	40/- to 45/-
Beans	33/- to 40/-
Peas	27/6 to 30/-
Rubbly Culm	15/- to 16/-
Steam Coals:	
Large Ordinary	22/6 to 24/6

FUEL OIL.

Inland consumption: contracts in bulk.

Exclusive of Government tax of 1d. per gallon; and 9d. per gallon on oil for road vehicles.

Ex Ocean Installation—	Per Gallon.
Furnace Oil (0·950 gravity)	3¼d.
Diesel Oil	4¼d.

French Engineering Notes

(From our own Correspondent in Paris)

Armament Profits

OWING to the unsatisfactory results of the existing method of limiting profits on armament production, the Minister of Finance appointed a commission to work out another system which is to be put into operation immediately. All the details of the system are explained in no fewer than seven pages of the official journal. It aims at the elimination of excessive profits on work for national defence without lessening inducements to manufacturers to make the fullest use of their initiative and capital in completing the country's defensive equipment, while facilities are offered to medium and small firms all over the country to take part in the work. Profits will be limited to a percentage of the annual turnover of business for defensive requirements, which will be separated from private work by special accounts adopted uniformly by all firms executing orders for national defence, so that they can be immediately verified and any concealment of profit is impossible. There is, nevertheless, some elasticity of the profit limitation plan whereby manufacturers are encouraged to do their best. The remuneration of individual makers and of heads of limited liability companies directly responsible for the execution of contracts will be included in overhead charges. Furthermore, as a means of favouring invention the use of new processes of importance in national defence will release the normal remuneration for such inventions from the limitation scheme. Nor will premiums paid for an acceleration of work come within the scope of profit limitation, and the same exemption is extended to the rapid amortisation of capital for the purchase of new machines that can only normally be used for the execution of contracts for national defence. There are other reservations with the object of enabling manufacturers to make what the State regards as a reasonable profit and increasing that profit by an acceleration of work, greater efficiency, and a lowering of production costs. The system gives to the State absolute control over the work. The amount of profit made is stated in proportion to the annual turnover, and the tax on excess profits increases with the higher percentage of profit to turnover. It starts with a tax of 25 per cent. on profits representing less than 4 per cent. of the turnover, to which are added 50 per cent. for the difference between 4 and 6 per cent., 75 per cent. between 6 and 10 per cent., and the whole of the profit above what is equal to 10 per cent. of the turnover. It is affirmed that this arrangement leaves a reasonable return on capital of between 5 and 10 per cent., less the usual taxes.

Hydro-electric Supplies

As rivers taking their rise from glaciers in the Alps fall through narrow and deep gorges it sometimes happens that a power-house can only be installed centrally at the base of the dam, of which it forms a part, and in the absence of spillways, the water falls in chutes over the power-house. This is the case with the Laigle dam now under construction on the lower Dordogne, and the same type has been adopted for the Saint-Etienne-Contales dam on the Dordogne tributary La Cere. The height of the dam will be 230ft. and the length at the crest 886ft. As the volume of water carried by glacier rivers varies considerably in winter and summer, it is intended to build a compensation dam about 1¼ mile farther down where the difference in levels allows of a height of 59ft., which will impound sufficient water to provide supplementary energy for peak loads, particularly in winter. The annual production will be 250 million kWh. Preliminary work now completed consists of a diversion tunnel, 20ft. in diameter, driven through granite, and two reinforced concrete retaining dams constituting a cofferdam for the construction of the new barrage. On the completion of these works the amount of energy obtainable from the valley of La Cere will be 470 million kWh a year. A new period of hydro-electric enterprise has been entered upon after several years of complete stagnation, when it was believed that the power stations already in operation were capable of supplying more energy than the country could use. There was reason for this belief so long as the industrial slump had reduced consumption and the State tied the hands of distributing companies to an extent that deterred capital from embarking on new hydro-electric enterprises. A good deal of work already in hand had to be suspended. Then the State became alive to the necessity of fully developing the country's hydro-electric resources. Industry was becoming more active, and the activity grew with the carrying out of the armament programme. The national electrification scheme was being completed, and organised propaganda in favour of electricity was undertaken to widen its applications. The view, based upon progress shown in yearly returns, that production would, in a relatively short time, be insufficient for the country's needs, led to a big financial effort to complete existing works and put new works in hand, so that there is every probability of the State Technical Committee, comprising all interests, successfully carrying out plans for the utilisation of all available hydraulic resources.

Machine Tools

The imports of machine tools during the month of June, valued at 93 million francs, exceeded those for the whole of 1938, when the total value was 81½ million francs. French makers are fully employed on the needs for national defence, and orders in hand will keep them busy for a long time to come, but these recent large imports of machine tools are causing them anxiety. They have considerably increased their means of production and fear that when the activity for national defence ceases they may find themselves in a precarious situation. It was hoped that the purchasing committee would have distributed orders in such a manner as to utilise the home manufacturing resources to better advantage and lessen buying abroad. The different State services, however, continue to specify the makes of machines they require. It is felt that importations will lead eventually to a redundance of machine tools that may seriously burden the French market.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES

509,087. July 1st, 1938.—PISTON OR PLUNGER FOR ENGINES, PUMPS, AND THE LIKE, Claude Stanley Over, 655, Mount Albert Road, Auckland, New Zealand.

The piston is made generally of the known form; the head end is of the usual working fit for the cylinder, and is provided with the ordinary grooves to accommodate rings. The skirt portion, however, is made so that its external periphery taperingly increases in diameter from the head end to its lower end, the amount of taper being very slight. This skirt is made with a number of narrow slots extending in the helically curving lines shown in the drawings. Sufficient of these slots are formed and made of such a width that the skirt is capable of compression in its diameter in order that it may fit within its cylinder, and

Nº 509,087

Fig.1

Fig.2

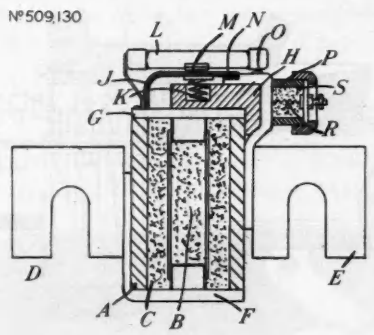
by its resilient expansion make the close fit, with wear-compensating properties. The edges of the slots also serve to scrape the inside surface of the cylinder bore and to distribute the lubricating oil. To aid this function of the slots, each one is shaped as shown in Fig. 2, to cause the inner edge to be sharp, while the outer edge is chamfered or bevelled. The chamfered edge is pierced with holes at intervals. It is desirable that for the purposes of strengthening the piston, its outer end should be more or less of a rigid nature, while still retaining the tension requisite for the expansion and contraction of the skirt. For this purpose, each slot, as it approaches the outer end of the piston skirt, is narrowed down and then given a reverse angle to provide an interlocking action between the slot edges, which will result in a compact skirt end.—*July 11th*, 1939.

ELECTRICAL APPLIANCES

509,130. January 14th, 1939.—ELECTRIC FUSES, The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C.2.

The invention has for its object to provide a cut-out which is capable of remote control and of dealing with instantaneous or prolonged overloads. The main fuse consists of the closed cartridge A with the fusible conductor B embedded in the filling material C, and having the two terminals D and E. The terminal D is in direct connection with the lower contact plate F, while the terminal E is indirectly connected with the upper contact plate G, being separated therefrom by the insulating piece H. The electric connection between the terminal E and the upper contact plate G is made on the one side through the laminated contact J with large cross section under the control of the spring K, and on the other side through the closed auxiliary fuse cartridge L, under the control of the spring M. The contact piece J is connected at the soldered point N and the auxiliary fuse at the soldered point O with a part of the terminal E. Both soldered points are thus connected in parallel, the solder at the point O, however, attaining its melting point in a longer period than that at the point N by using solder having a higher melting point at the point O. The heating device is provided in the neighbourhood of the two soldered points N and O. It consists of a container P

Nº 509,130

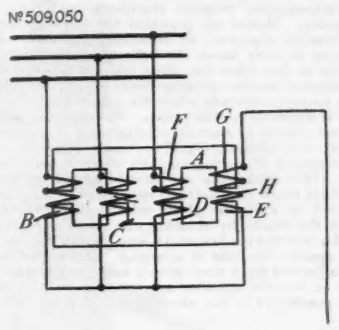


filled with a compound which rapidly generates heat when initially heated by wire R. In the case of forward current the main fuse responds for excess current and short circuit and the fusible conductor B melts. The contact piece J and the soldered point N are of such dimensions that in the range of moderate excess currents the soldered point N opens first owing to the heating effect of the current on the solder so that the whole current passes through the auxiliary fuse L and the circuit of the fuse L is interrupted. The fusible conductor in the auxiliary fuse consists of a silver wire with a solder coating of lead, tin, or an alloy which delays the response of the fusible conductor. In the case of reverse current in all cases the heating device P is set in operation even when dealing with a short-circuit current, which makes the main fusible conductor respond and an opening of the soldered point would not be required. For such reverse current the striking compound S in the striking head P is made to strike by a relay. Through the heat thereby engendered the soldered point N with the lower melting point is first opened. The opening occurs without arcing, as the current can still flow through the auxiliary fuse L, and the soldered point O. The circuit is then broken at the soldered point O, as long as, under the action of the current to be disconnected, the delay of the fusible conductor in the cartridge L is greater than the thermal inertia of the soldered point O. In this manner, the current to be interrupted at the soldered point O can be made a safe amount by corresponding dimensions of the auxiliary fuse L. For greater currents the final interruption takes place in the cartridge L before the soldered point O opens.—*July 11th*, 1939.

509,050. December 10th, 1937.—ELECTRICAL REACTORS, The General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C.2, and Reinhold Rudenberg, of Research Laboratories of The General Electric Company, Ltd., Wembley, Middlesex.

This invention relates to electrical reactors and in particular to reactors for compensating both the running charging current and the earth capacity current of an electric transmission line. The reactor comprises a core A with four parallel limbs, B, C, D, E, each having an air gap, shown as a single gap, but preferably subdivided into a number of small gaps distributed along the length of the limb. The phase windings, each wound or connected in the same sense between a phase conductor and a star point, are carried on three adjacent transverse limbs of the core. The fourth limb E of the core, which carries any out-of-balance flux from the three phase limbs, carries a further winding connected between the star point and earth, and is wound or connected in a sense opposite to

Nº 509,050



the phase windings. For the connections shown this winding is wound in the same sense as the phase windings. When an earth fault occurs on one line—for example, the line to which the winding F is connected—the winding G carries the resultant current of the phase windings, and the magnetic potential produced by the winding G acts in the same sense as the flux in the limb E, which is the return flux from the limbs B, C, and D. By suitably proportioning the number of turns of the winding G with respect to the phase windings and the area and length of the air gap H, it is possible to eliminate the excessive magnetic potential between the yokes which occurs under fault conditions with earlier arrangements. The phase windings are provided with tapping points in order that the reactor current may be varied to compensate for any increase in the normal charging current due to an extension of the transmission line. The winding G is also provided with tapping points so that the compensation for the charging current under fault conditions may be separately adjusted.—*July 10th*, 1939.

LOCOMOTIVES

508,614. April 19th, 1938.—IMPROVEMENTS IN RAILROAD TRAINS, Edward G. Budd Manufacturing Company, 2500, Hunting Park Avenue, Philadelphia, Pennsylvania, United States of America.

This invention relates to railway trains, and more particularly to streamlined trains propelled by a motor of the internal combustion engine type. Its object is to provide improved means for cooling and scavenging the interior of the motor unit and for causing a flow of air through the motor cooling radiators. Another object is to devise a streamlined train made up of a series of cars, the end units of which are identical, and to devise a motor unit having a rear end constructed to co-operate with either end car of the series, whereby the motor unit may be coupled to either end of the train as desired. Referring to the drawings, A designates the motor unit, B the end units of the series of cars, and C the intermediate car units. The motor unit, which is shown as of the so-called oil-electric type, contains a main internal combustion engine D coupled to a generator, and an auxiliary engine E. At the forward end of the motor unit is the driver's compartment, separated from the main compartment or interior of the unit by means of a bulkhead F, and also provided with

Nº 508,614

Fig.1

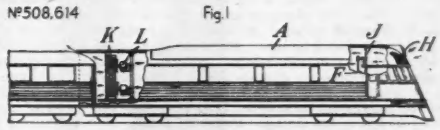


Fig.2

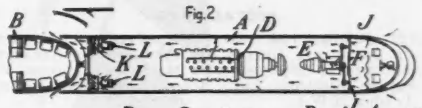
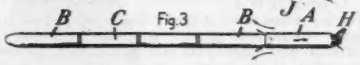


Fig.3



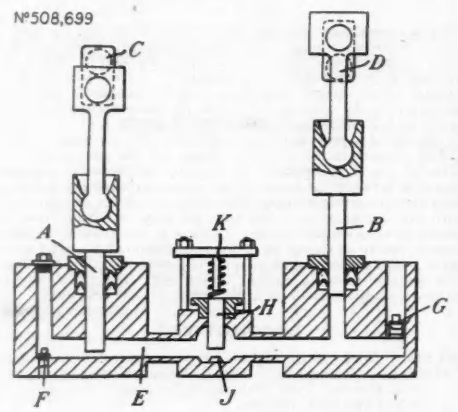
a horizontal partition connected with this bulkhead. Grilled openings H are provided at the front of the motor unit at a point above the partition, and openings are formed in the bulkhead F through which air entering through the grilled openings may freely pass. In order to assist the natural draught in causing a free flow of air through these openings, fans J may be mounted therein. At the rear of the motor unit are mounted the radiator or radiators K which are connected with the main engine by suitable piping (not shown). As illustrated, two such radiators are provided, one at each side of the unit and extending substantially the full height thereof. In order to force air through these radiators fans L may be provided. The rear wall of the motor unit immediately behind the radiators is open in order to permit free passage of air through the radiators. The rear edge of the floor or lower portion of the motor unit is concave as shown at Fig. 2, and the ends of each of the end cars B are rounded or tapered as shown. This rounding is preferably of such shape as to provide a car end of substantially streamlined form. The side walls of the motor unit A extend rearwardly on each side of and embrace the rounded or tapered end of the car unit B, the rear edges of these walls being spaced from the curved walls of the rounded or tapered car end. Thus the rear end of the motor unit is provided with a recess into which the rounded or tapered end of the car unit is received. The flow of air past the walls of the motor unit and car unit, due to the forward travel of the train,

will produce a venturi or aspirating effect in the spaces between the walls of the respective units, and this aspirating effect will tend to draw air rearwardly through the interior of the motor unit from the grilled openings past the radiators and out of the openings, the interior of the motor unit being, of course, open and unobstructed, so that air may flow therethrough. In order to increase this movement of air through the interior of the motor unit and past the radiators, fans are preferably employed. A car unit such as B, having a rounded end, may be provided at each end of the series making up a train, so that both ends are identical, and a motor unit such as A may be coupled to either end as desired. This avoids the necessity of turning trains around at terminals, and results in the rear end being of streamlined form, regardless of the direction of movement.—*July 4th*, 1939.

PUMPING AND BLOWING MACHINERY

508,699. January 5th, 1938.—Variable-output Reciprocating Pumps, Callender's Cable and Construction Company, Ltd., Hamilton House, Victoria Embankment, London, E.C.4, and George Thomas Wilson Grieve, of the company's address.

This invention relates to variable-output pumps of the type in which the output is varied by altering the phase relation between the cycle of movement of two similar pumping units working at the same speed either in the same pressure chamber or in interconnected pressure chambers, each unit being a plunger pump. Means are provided for allowing the volume of the pressure chamber, or combined pressure chambers, of the pump to vary under the influence of pressure between small limits so that when the phase relation between the cycles of movements of the two pumping units is such that one plunger is always moving outwards while the other is moving inwards, no liquid is delivered by the pump. The pump consists of two units of the normal plunger type, consisting of plungers A and B coupled to crankshafts C and D, but working in a common pressure chamber E having an inlet valve F and a delivery valve G. The crankshafts are interconnected by means (not shown) which cause the shafts to rotate at the same speed, but are adapted to vary the phase relation between the rotary motion of the shafts by rotating one shaft relatively to the other. An auxiliary plunger H also moves in the pressure chamber against the bias of a spring. The movement of the plunger is limited by a fixed stop J and an adjustable stop K mounted on a cross member supported by rods. When the cycles of movement of the plungers A and B are 180 deg. out



of phase—that is, when one plunger is always moving inwards while the other is moving outwards—the accelerations of the plungers are not at each instant equal in magnitude and there is some pumping action. The amount of liquid delivered in this condition of the pump depends upon the relation between the length of the connecting-rods and the length of the stroke of the two plungers. If the connecting-rods are of lengths equal to twice the stroke, the output of the pump; when the crankshafts are 180 deg. out of phase, is equal to approximately 10 per cent. of its maximum output. This delivery takes place in two parts during each complete cycle of the pump, and the total pumping action therefore consists of a delivery of approximately 5 per cent. of the maximum delivery of the pump during each half cycle. The auxiliary plunger is made to vary the volume of the pressure chamber by an amount slightly in excess of this small delivery (*i.e.*, 5 per cent. of the maximum delivery in the above example). When the crankshafts are 180 deg. out of phase, the auxiliary plunger will therefore oscillate with a frequency equal to twice the frequency of oscillation of each of the main plungers and will cause the volume of the pressure chamber to alter in such a way that the output of the pump is reduced to zero. By providing a pump of the type to which the invention relates with means for varying the volume of the pressure chamber in accordance with the invention, it is therefore possible to alter the output of the pump from the maximum to zero without changing the speed of the driving means of the pump.—*July 5th*, 1939.

METALLURGY

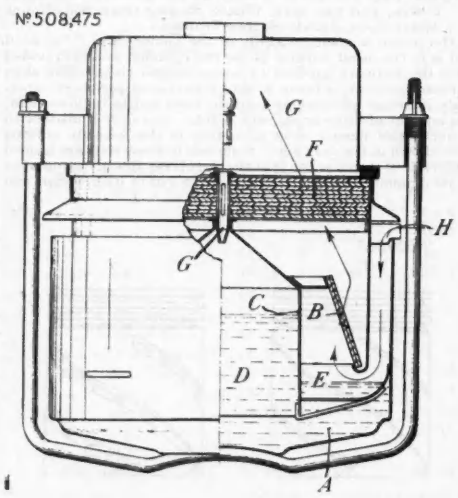
508,723. February 15th, 1938.—Process for the Production of Protective Layers on Aluminium or Aluminium Alloys and Magnesium or Magnesium Alloys, Magnesium Elektron, Ltd., Abbey House, Baker Street, London, N.W.1.

The invention aims at producing more compact and adherent fluoride coatings of greater and more uniform thickness on aluminium and magnesium and their alloys, irrespective of the composition of the latter, without applying heat. It provides a process for the production of protective layers by anodic treatment with the aid of a fluoride-containing electrolyte, which is characterised in that a saturated or almost saturated aqueous solution of a single neutral fluoride or silico-fluoride, the solubility of which in water is at least about 30 per cent. (30 grammes of anhydrous substance per 100 grammes of solution) at room temperature (20 deg. Cent.), is used as electrolyte. According to one example of the process, a work piece of a magnesium base alloy containing 2 to 3 per cent. of zinc and 5 to 6 per cent. of aluminium is treated anodically at ordinary temperature (20 deg. to 25 deg. Cent.) in an aqueous solution containing 30 per cent. of ammonium fluoride and, in addition, 25 per cent. of potassium fluoride. The voltage required to maintain a current density of about 2 amperes per square decimetre is about 60 to 80. After a treatment lasting four minutes the work piece is taken out of the bath, washed and dried. The coating produced exhibits an exceptionally uniform nature and is, at the same time, absorptive and therefore particularly suitable for subsequent consolidation and imparts to the work piece an increased resistance to corrosion.—*July 5th*, 1939.

MISCELLANEOUS

508,475. December 28th, 1937.—Air or Gas Filters or Purifiers, Hans Wittemeier, Schweidnitzer Strasse 11/15, Berlin-Halensee, Germany.

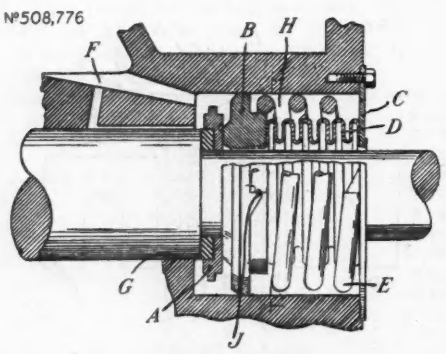
The type of air or gas purifier shown in the accompanying drawing consists of a casing, the lower part A of which serves to receive the moistening liquid (preferably oil). Above the moistening liquid is arranged the filtering layer B serving to purify the air or other medium. Within the filter cone is provided a hollow member C, which is open at the bottom and projects into the liquid space and divides it into the two chambers D and E. The liquid in these two chambers is interconnected, but only the liquid in the outer chamber, which liquid is thus partly located under the filtering cone, comes into contact with the air to be purified. Looking in the direction of the air current, there is arranged behind the filtering layer B a filtering cartridge F, which is intended for the fine purification of the air. In the crown of the bell C there opens a pipe G, open at both ends providing a connection between the chamber D and the space G behind the filtering cartridge. The pipe is constructed in the form of a nozzle at the end projecting into the hollow member C for the purpose of preventing passage of the liquid. Slits are provided in the walls of the pipe to connect the chamber D with the interior of the cartridge. The air or gas to be purified passes through the annular opening H into the



purifier, flows downwards in the duct formed by the outer wall of the casing, and the wall of the hollow cylinder, and impinges on the liquid present in the chamber E, which is swept over for substantially the whole of its breadth. The liquid is thereby set into undulatory movement and flushes the filtering layer B continuously. The air stream, which reverses its direction of flow above the level of liquid in the chamber, then passes through the filtering layer from the inside to the outside, whereby it is freed from its impurities. The air then flows on in the direction of the arrow through the cartridge and on to the outlet in the hood. When the purifier is not in operation the liquid present in the fluid space A stands at an equal height in the two chambers, since then the air pressure is equal on both the liquid surfaces. Only when the filter is set into operation does there occur a pressure difference between the spaces before and behind the filtering layer, which difference is larger or smaller corresponding to the larger or smaller load of the purifier and by which difference the adjustment at different heights of the liquid levels in the two chambers is automatically effected.—*June 28th*, 1939.

508,776. March 7th, 1939.—Shaft Seals, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2.

The seal described relates particularly to those employed for preventing leakage around the shafts of refrigerant compressors. The drawing shows a portion of a refrigerant compressor casing provided with a boss counterbored to provide a chamber. A drive shaft is journalled in a bearing aperture in the casing which provides communication between the interior of the casing and the chamber. The shaft is of reduced diameter near its outer end and is provided with a shoulder slightly beyond the bearing aperture. The outer end of the shaft extends through the chamber to the outside of the compressor casing and is driven by a suitable source of power. In order to prevent the escape of the gaseous refrigerant and other fluids contained in the casing, there is provided a sealing arrangement, including a removable collar A mounted on the shaft abutting on the shoulder thereof. The removable collar is substantially L shaped in cross section and has an annular recess about its inner side. A ring of resilient material is under compression



in the recess and forms a seal between the shaft and the collar, and also prevents relative rotation between the shaft and the collar. The collar is provided with a transverse sealing surface. A sealing ring B is arranged so that its sealing surface is in running engagement with the sealing surface of the collar A. In the open end of the chamber is arranged a disc C. In order to seal the ring B to the casing there is provided a resilient metallic bellows D extending between the ring B and the disc C, the opposite ends of the bellows being hermetically sealed to the adjacent portions of the ring and the disc respectively. The ring B has an annular flange which engages the walls of the counterbore and positions the ring within the chamber so that its sealing surface is squarely aligned to engage the sealing surface of the collar A. A helical compression spring E surrounds the bellows and extends between the flange of the sealing ring and the disc, and presses the ring B in engagement with the surface of the collar and maintains an effective seal. The spring is maintained in its position by a portion of the ring having the same diameter. During the operation of the compressor, some lubricant is thrown into a recess F formed in the top of the bearing structure. A portion of this lubricant flows by gravity through a passage and a longitudinal groove to lubricate the bearing G. Another portion flows through a passage into the chamber H where it is trapped and retained, thereby maintaining the seal flooded. During the starting operation, particularly after long periods of idleness, there is a tendency for the sealing surfaces to drag momentarily due to starting friction. Torsional stresses are transmitted to the bellows from the ring, and the repetition of the stresses may in time cause breakage of the bellows. In order to prevent the transmission of stresses to the bellows, the spring is so arranged that it will absorb the torsional stresses transmitted to the ring and minimise the twisting of the bellows and their possible breakage. In order to transmit the stresses from the ring to the spring, there is a stop or abutment J on the flange engaging the inner end of the spring, and a similar stop on the inner side of the plate C engaging the outer end of the spring. The spring is wound in a direction to oppose rotation of the ring with the shaft.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Engineering and Marine Exhibition

Thursday to Saturday, Sept. 14th to 30th.—Olympia, London, W.6.

Institute of Metals

Tuesday to Friday, Sept. 5th to 8th.—Autumn meeting in Glasgow.

Institution of Electrical Engineers

Friday to Sunday, Sept. 15th to 17th.—Transmission Section. Summer visit to Yorkshire.

Institution of Mechanical Engineers

Saturday to Sunday, August 26th to October 1st.—American Summer meeting.

Iron and Steel Institute

Tuesday to Friday, Sept. 12th to 15th.—Autumn meeting in Cardiff.

CONTRACTS AND ORDERS

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

H. Puffett and Co., 91 and 93, Bishopsgate, London, E.C.2, have received from Paramount Theatres, Ltd., a contract to fit the boilers in all their London Astoria cinemas with "Abato" furnaces.

The Brightside Foundry and Engineering Company, Ltd., Sheffield, has obtained a contract from the Aluminium Union, Ltd., for aluminium rolling mill plant for delivery to its associate, the Australian Aluminium Company Proprietary, Ltd., Sydney. This plant will comprise a two-high breaking down mill with tilting tables and three stands of sheet-finishing mill rolls.

PERSONAL AND BUSINESS ANNOUNCEMENTS

Mr. F. Le Neve-Foster has been appointed to the Board of Crompton Parkinson, Ltd. Mr. Le Neve-Foster is a member of the firm of Warren, Murton, Foster and Swan, solicitors, and has been associated with the company for many years. He is also a director of the Stanton Ironworks Company, Ltd., and other public companies.

LAUNCHES AND TRIAL TRIPS

Aska, steamship; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of the British India Steam Navigation Company, Ltd.; dimensions, length 460ft., breadth 61ft. 3in., deadweight 6200 tons. Engines, twin-screw turbines, pressure 450 lb. per square inch; trial trip, August 1st.

Thiara, motor tank ship; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of the Anglo-Saxon Petroleum Company, Ltd.; dimensions, length 500ft., breadth 64ft. 3in., depth 37ft. Engines, ten cylinder, four stroke, solid injection; constructed by R. and W. Hawthorn, Leslie and Co., Ltd.; launch, August 1st.

Waiotira, motor cargo liner; built by Harland and Wolff, Ltd., to the order of Shaw Savill and Albion Company; dimensions, length 535ft. 6in., breadth 70ft., depth 43ft. 4in., gross tonnage 11,200. Engines, two, six cylinder, two stroke, double acting; launch, August 1st.

CATALOGUES

Switchgear and Cowans, Ltd., Manchester, 16.—Brochures on truck cubicle switchgear and A type circuit breakers.

Baxendale and Co., Ltd., Miller Street Works, Manchester, 4.—Pocket catalogue of electric light and power accessories.

Hepworth and Grandage, Ltd., St. John's Works, Bradford.—1939 catalogue of pistons, piston rings, gudgeon pins, cylinder liners, &c., for all types of motor vehicles.

Thos. Firth and John Brown, Ltd., Atlas and Norfolk Works, Sheffield, 1.—Souvenir brochure issued in connection with the visit to the works of the Forfeit Feast Guests and of the Master and Mistress Cutler. It illustrates typical sections of the works and their products.

Westinghouse Brake and Saxby Signal Company, Ltd., 82, York Way, King's Cross, London, N.1.—A number of revised sections for the company's loose-leaf catalogue, also a brochure on the resignalling of the Portsmouth, Mid-Sussex, and Coastal Lines of the Southern Railway.